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by

GEOFFREY FRYER

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in Northern England** — *John D. Altringham, Susan O'Brien and
Sydney Julian*

**Changes in the Distribution of Reptiles in the East Riding of
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FEEDING ECOLOGY OF LITTLE OWLS (*ATHENE NOCTUA*) AT AN UPLAND SITE IN NORTHERN ENGLAND

JOHN D. ALTRINGHAM, SUSAN O'BRIEN AND SYDNEY JULIAN

Department of Pure and Applied Biology, University of Leeds, Leeds LS2 9JT

SUMMARY

Seasonal changes in diet of a pair of little owls (*Athene noctua*) have been studied over 4 years (from November 1988) by the analysis of monthly collections of pellets. The owls roosted and nested in a disused quarry at an elevation of 290m on open moorland. Upland sites are used by a high proportion of little owls in West Yorkshire. Field voles (*Microtus agrestis*) are the major dietary component (61% by weight), with earthworms (*Lumbricus* spp.) the second largest (17%). The relative proportions by weight of the principal prey types are: mammals, 72.4%; invertebrates, 20.4%; birds, 4.5%; reptiles and amphibians, 2.7%. Reports on previous studies of the diet of the little owl have expressed dietary components in terms of the number of each prey type taken, with consequent emphasis on invertebrate prey. However, comparison by weight suggests a broadly similar diet within Britain, although significant variation is seen across Europe. There is substantial overlap of both habitat and diet between owls resident in the U.K., and it is possible that the little owl, an introduced species, is a competitor of some of our native owls. Significantly fewer field voles and earthworms are taken in summer than at other times of the year, and a range of other prey are taken, apparently opportunistically, to make up the deficit. Possible reasons for these, and other, seasonal variations in diet are discussed.

INTRODUCTION

The little owl (*Athene noctua*) is widespread in Europe, but is not native to the British Isles. It was first introduced in Yorkshire in about 1843, to control garden pests such as insects and mice (Hibbert-Ware, 1938). This introduction was unsuccessful, but further attempts around the country followed, and from centres in Northamptonshire and Kent it has spread widely since 1900, and is now a relatively common bird throughout England and Wales. In Britain it commonly inhabits open agricultural land interspersed with woods and copses, in which it roosts and nests (Cramp, 1985). Glue and Scott (1980) found that 74% of territories located were on farmland, 12% in woodland/gardens, and only 1% on moorland. Trees were the preferred nest site (92%). The little owl site in this study, a disused quarry on high heather (*Calluna*) and grass moorland therefore appears atypical. The site, near Keighley, in West Yorkshire, is 290m above sea level: of the 355 nests studied by Glue and Scott (1980) 99% were below 244m, 95% below 180m and 85% below 120m. Little owl territories are common at high altitudes in West Yorkshire (see discussion). There are several small coniferous (*Pinus*) plantations close to the crag, a small reservoir, three farms (pastoral) and several other buildings within 200-1000m. The owls roost and nest in cracks on the steep sides of the quarry, approximately 6m above the ground.

Surprisingly little work has been done on the diet of the little owl, with the only significant studies in the U.K. being carried out over 50 years ago (Collinge, 1924; Hibbert-Ware, 1938). Work carried out in Europe has been summarised by Mikkola (1983), Cramp (1985) and Exo (1992). Most published dietary information is expressed as a percentage of total prey taken by number, which can be misleading when prey are of very different sizes. This study assesses the relative importance of different prey, in terms of the percentage weight they contribute to the diet, and compares the results with those from previous studies of the little owl and other species. Seasonal trends in diet have also been studied and discussed.

MATERIALS AND METHODS

At the end of each month, from November 1988 until September 1992, all pellets which could be found by a careful search beneath the quarry roost sites were collected, and the contents analysed.

Analysis of pellets

All pellets were dried in a bottom heating plant propagator, for 7-14 days, immediately after collection. Their length and average diameter were measured, and each was allocated a reference number. Any fragments were put together to make average size pellets, but these made up <5% of the total material. Individual dry pellets were gently teased apart for analysis. Mammals were identified by the jaws or skulls (Yalden & Morris, 1990), and the number of individuals estimated from the minimum jaw/skull count. Bird skulls were never present (crushed by digestion or not swallowed by the owl) and the species were identified from bones or an occasional feather, using a reference collection from known species. In some cases the species could not be determined with any degree of certainty, but a size could be assigned with some confidence from bone lengths. Common lizards (*Lacerta vivipara*) were identified by their scales and frogs (*Rana temporaria*) by their bones.

After removal of the vertebrate material, the matrix of the pellet was examined under a stereomicroscope. Earthworm chaetae indicated the presence or absence of earthworms. A large adult worm weighs 5g (Yalden, 1985). It has been assumed from the size of the chaetae (virtually all >0.5mm) that small worms were not taken, and that each pellet with chaetae contained one large or several smaller worms of 5g total weight. Yalden's method of determining earthworm content by relating the weight of sand in the pellets to that obtained from digested earthworms was not feasible. It was very difficult to determine what component of the inorganic material might be from earthworms, and many pellets contained sand but no chaetae. It was also not known what proportions of sand and chaetae were lost in faeces. This measurement is therefore subject to some error, but the weight of earthworms per pellet is unlikely to be very much smaller, since very small earthworms do not appear to be taken. Nor is it likely to be too much greater: our estimate of the weight of prey eaten to produce one pellet (based on a large sample size, see results) is similar to that of tawny owls, despite a smaller pellet, and any increase in earthworm content will make this value even greater. Beetles, caterpillars and other invertebrates were estimated from the number of heads. A study of captive long-eared (*Asio otus*), tawny (*Strix aluco*) and barn (*Tyto alba*) owls showed that around 20%, 16% and 8% respectively of vertebrate prey were unaccounted for by subsequent pellet analysis (Raczyński & Ruprecht, 1974). Lowe (1980) performed a similar study on tawny owls, and found that mean annual losses ranged from 14% of field voles to 22% of wood mice, with other mammals falling between these values. In contrast, Mikkola (1983, p. 35) carried out similar studies on four species of owl, and found that pellets reflected exactly the animals fed to them. Work on the short-eared owl (*Asio flammeus*) by Short and Drew (1962) supports this latter view. No quantitative studies have been done on little owls. These results have been kept in mind in carrying out our analyses, and the effects of possible corrections looked at.

Analysis of data

The numbers of each prey item found in the pellets were calculated over the monthly intervals. Weights of live prey from the literature were used to calculate the monthly total weight of each prey item. All results, weight or number, either plotted or used in calculations, are minimum monthly totals divided by the number of pellets in that month, to compensate for monthly variation in the number of pellets collected. The prey weights used were taken from Yalden (1985) and Yalden and Morris (1990), and bird weights obtained from British Trust for Ornithology records and recorders (see Table 1). An average weight for a wild common lizard was taken as 2.5g (R. Avery *pers. comm.*) although the published value for captive specimens is 3.5g (Avery, 1975).

ANOVA was performed on the numbers of pellets collected in each month, and also by pooling data into three month seasons (December-February = winter, March-May = spring, and so on), over the four year period, to test for any significant annual trends. Similarly, variation in diet (prey weight per pellet) was also examined by ANOVA. Pearson's Correlation was used to detect any correlations between the seasonal trends of different prey items in terms of number per pellet. The monthly numbers of prey were also tested

against the average monthly rainfall, temperature and snowcover. Weather information was obtained from the Leeds Weather Centre, Bingley Station, recorded approximately 5km from the study site. All statistical tests were performed using Microsoft Excel or GraphPad Stat.

RESULTS

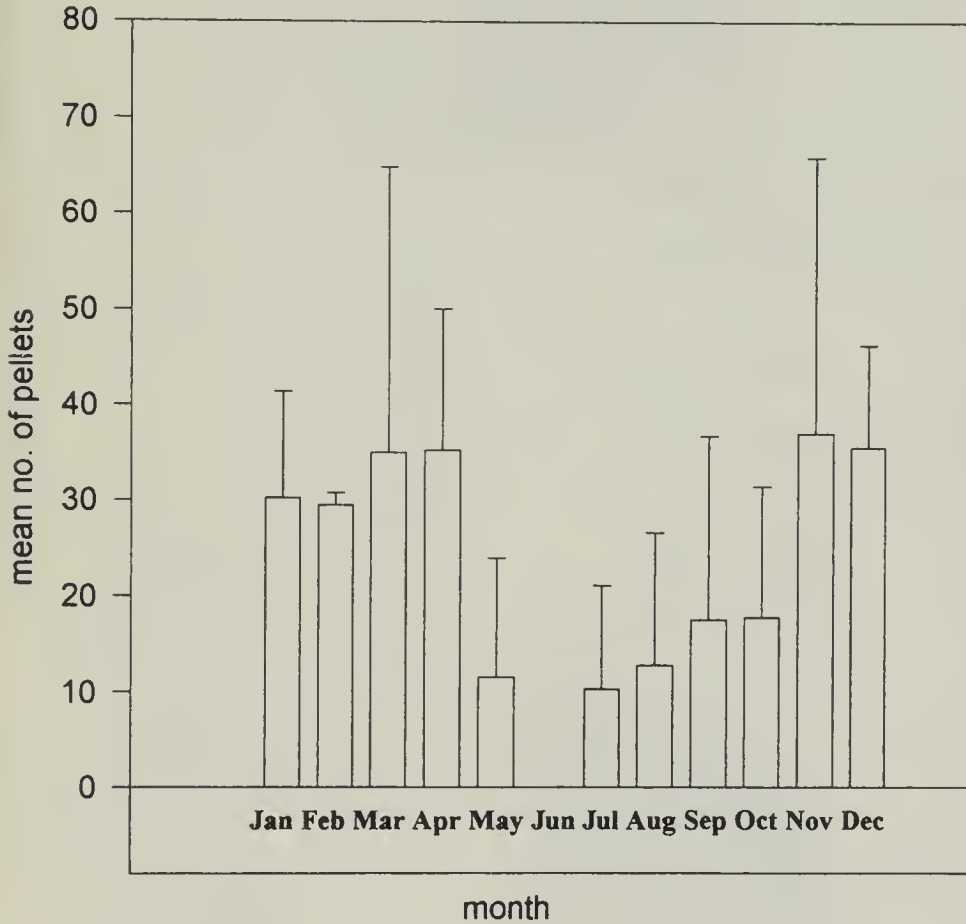


FIGURE 1

Mean $\pm$ s.e. ($n = 4$) of number of pellets collected each month over the four year study.

Figure 1 shows the mean number of pellets found in each month over the four years of the study. The number of pellets collected varied significantly ($P < 0.05$) when tested by month and season, with more found in winter than summer and none ever found in June. A random sample of pellets had an average length of 28.8 ± 0.9 mm, a diameter of 13.8 ± 0.2 mm and a mean weight of 1.18g ($n = 65$). The mean total prey weight per pellet was 0.1 ± 0.6 g (mean $\pm$ s.e., $n = 37$ months), calculated from live weights of all prey over each month.

Table 1 summarises the contents of the 1089 pellets analysed over the four year period. In Figure 2A the proportion by number of each prey category is shown. Figure 2B shows the proportion by weight each prey category contributes to diet. Large numbers of beetles, earthworms, caterpillars and field voles were taken, but by weight field voles are by far the most important prey item. Mammals comprise 72.4% of the diet, other vertebrates 7.2% and invertebrates 20.4%, with 17% of the latter made up of earthworms. No corrections have been made for differential losses in digestion, since data are available only for mammals eaten by other species of owl, and the results are contradictory (see methods).

TABLE 1

Summary of little owl diet. Prey weight (%) is the prey by weight, expressed as a % of the weight of all prey. All values for prey weight are from Yalden and Morris (1990), and from K. Capps and P. J. K. Burton for birds. (1) Bird weights are calculated by assuming a mean weight of 15g unless the bird was identified. (2) Weight *pers comm.* R. A. Avery. (3) Weight – author's own measurements (4) Yalden, D. W. (1985). The numbers of individuals of each species of bird are not given due to the uncertainty of identification of some specimens.

PREY		Total number of prey	Prey weight (g)	Prey weight in diet (% of total)
MICROTINES				
Field Vole	<i>Microtus agresis</i>	515	21	60.78
Bank Vole	<i>Clethrionomys glareolus</i>	16	16	1.44
MURIDS				
Wood Mouse	<i>Apodemus sylvaticus</i>	14	18	1.42
Brown Rat	<i>Rattus norvegicus</i>	10	60	3.37
SHREWS				
Common Shrew	<i>Sorex araneus</i>	77	8	3.46
Pygmy Shrew	<i>Sorex minutus</i>	87	4	1.95
BIRDS				
	Total	43	See (1) above	4.53
Goldcrest	<i>Regulus regulus</i>		5.5	
Blue Tit	<i>Parus caeruleus</i>		10.5	
Wren	<i>Troglodytes troglodytes</i>		10.5	
Great Tit	<i>Parus major</i>		18.5	
Robin	<i>Erithacus rubecula</i>		18.5	
Meadow-Pipit	<i>Anthus pratensis</i>		18.65	
Chaffinch	<i>Fringilla caelebs</i>		22	
Skylark	<i>Alauda arvensis</i>		26.75	
Greenfinch	<i>Carduelis chloris</i>		28.5	
House-Sparrow	<i>Passer domesticus</i>		29	
Song-Thrush	<i>Turdus philomelos</i>		85	
Blackbird	<i>Turdus merula</i>		98	
Mistle-Thrush	<i>Turdus viscivorus</i>		135	
REPTILES				
Common Lizard	<i>Lacerta vivipara</i>	93	2.5 See (2) above	1.31
AMPHIBIANS				
Common Frog	<i>Rana temporaria</i>	12	20	1.35
DERMAPTERA				
Total		986	0.25 See (3) above	1.39
and				
COLEOPTERA				
Earwig	<i>Forficula auricularia</i>			
Ground Beetle	<i>Bembidion</i> species			
	<i>Thanatophilus rugosus</i>			
LEPIDOPTERA				
Moth heads, eggs and caterpillars		350	1 See (3) above	1.97
ANNELIDA				
Earthworms	<i>Lumbricus</i> species	606	5 See (4) above	17.03
TOTAL		2809		100

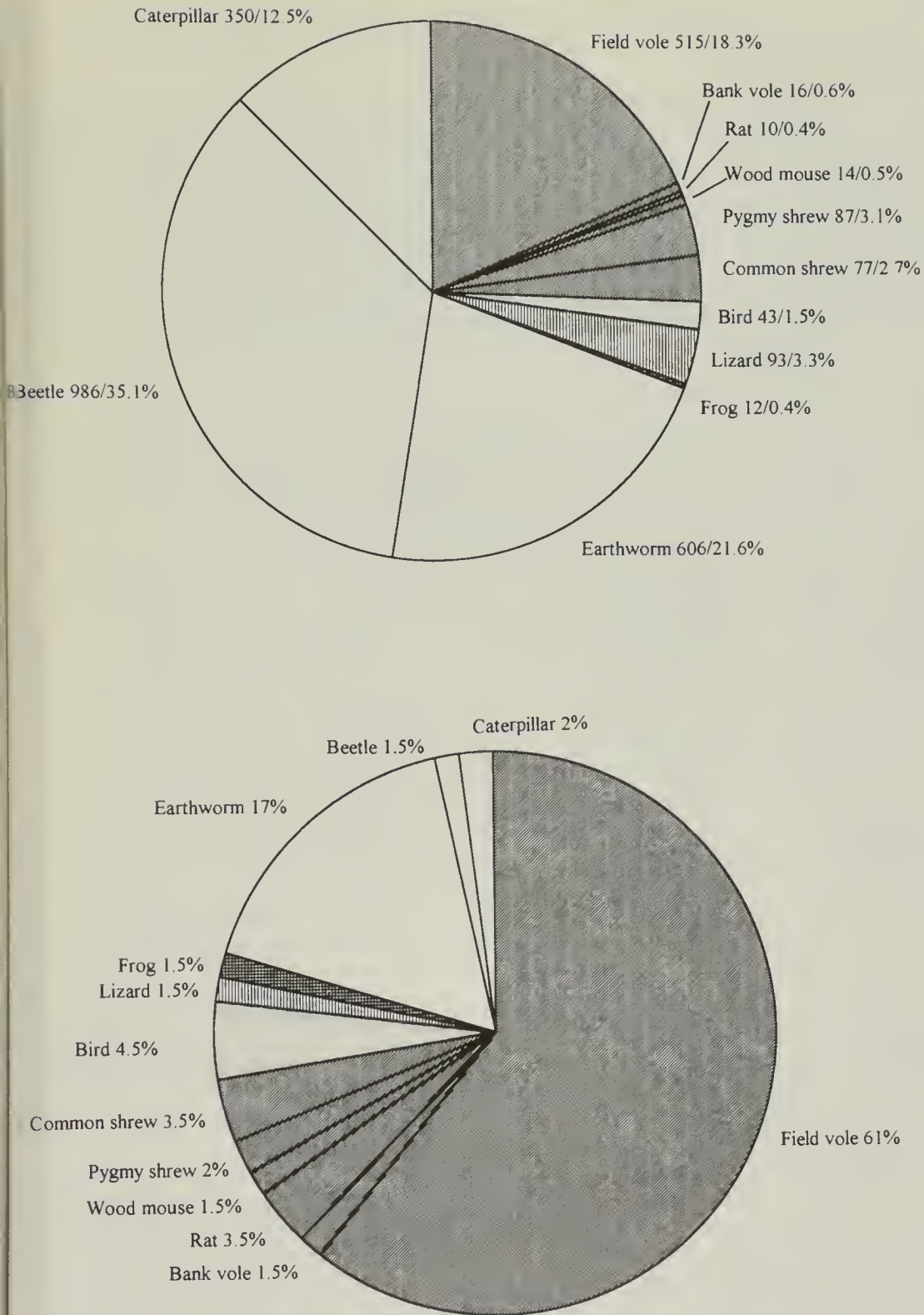


FIGURE 2

Prey items identified in pellets collected over the four years of the study.

(a) Prey expressed as a % of the total number of prey.

The figures give the number of prey followed by the % of total prey.

(b) Prey items as a % by weight of total prey weight.

The most common birds taken are blue tit, great tit, chaffinch, goldcrest and meadow pipit. Other species were taken in very small numbers. Evidence of mole was found in 1993, after our study period.

Monthly changes in percentage of prey by weight, averaged over the four years, are shown in Figure 3. It should be noted that no pellets were collected in June, and the June column in all plots is not a zero, but an absence of an entry. Field voles made up over 60% of the diet in winter and spring, but this fell to an average of about 40% in summer. Earthworms were also taken less frequently in summer, and a variety of other prey items compensated for the fall in these two major food sources. These included common shrew, wood mouse, frog, bird and rat.

The variation in the weight of field voles taken showed significant seasonal variation ($P < 0.001$, ANOVA) (Fig. 3) with more being taken in winter/spring than summer/autumn. A similar, significant ($P < 0.001$) trend was seen for earthworms. More lizards are taken in summer than winter ($P < 0.05$).

TABLE 2
Results of Pearson's Correlation analyses of prey-prey and prey-weather relationships.
The first two columns give the two variables tested. r = correlation coefficient,
n.s. = not significant.

field vole	earthworm	$r = 0.725$	$P < 0.05$
common shrew	pygmy shrew	$r = 0.531$	$P < 0.05$
bird	beetle	$r = 0.491$	$P < 0.05$
field vole	all other prey		n.s.
earthworm	all other prey		n.s.
field vole	temperature	$r = -0.563$	$P < 0.05$
field vole	snow cover	$r = 0.287$	n.s.
earthworm	rainfall	$r = 0.430$	n.s.
earthworm	temperature	$r = -0.580$	$P < 0.05$
beetle	temperature	$r = 0.023$	n.s.
lizard	temperature	$r = 0.110$	n.s.
snow cover	temperature	$r = -0.497$	$P < 0.05$

Table 2 summarises the results of a Pearson's Correlation test for possible inter-dependence in the month by month changes in the number/pellet of each prey item. The table gives values for prey items tested against each other, and against the weather. At the 5% level of significance, one in twenty of the significant correlations may be an anomaly. To correct for this, the level of significance has been divided by the number of tests carried out (Rcyment *et al.*, 1984). The main points of interest are as follows.

There is a positive correlation between the number of field voles/pellet and the number of earthworms. This is very unlikely to be due to a common causal factor. Both decline with increasing temperature, in agreement with the significant decline in their importance as prey items by percent total weight in summer (Fig. 3). The number of earthworms/pellet decreases as rainfall decreases although the relationship is not quite significant at the 5% level. The numbers of common shrews and pygmy shrews are positively correlated, as are the numbers of birds and beetles. No correlation was found between the number of field voles or earthworms/pellet and any other prey item. No correlation was found between the number of field voles and snow cover. The number of beetles taken was not correlated with temperature. No correlation was found between lizards and temperature, but most were caught in spring and summer, and a significant seasonal trend was noted (see above and Fig. 3). Snow cover and temperature were correlated as expected.

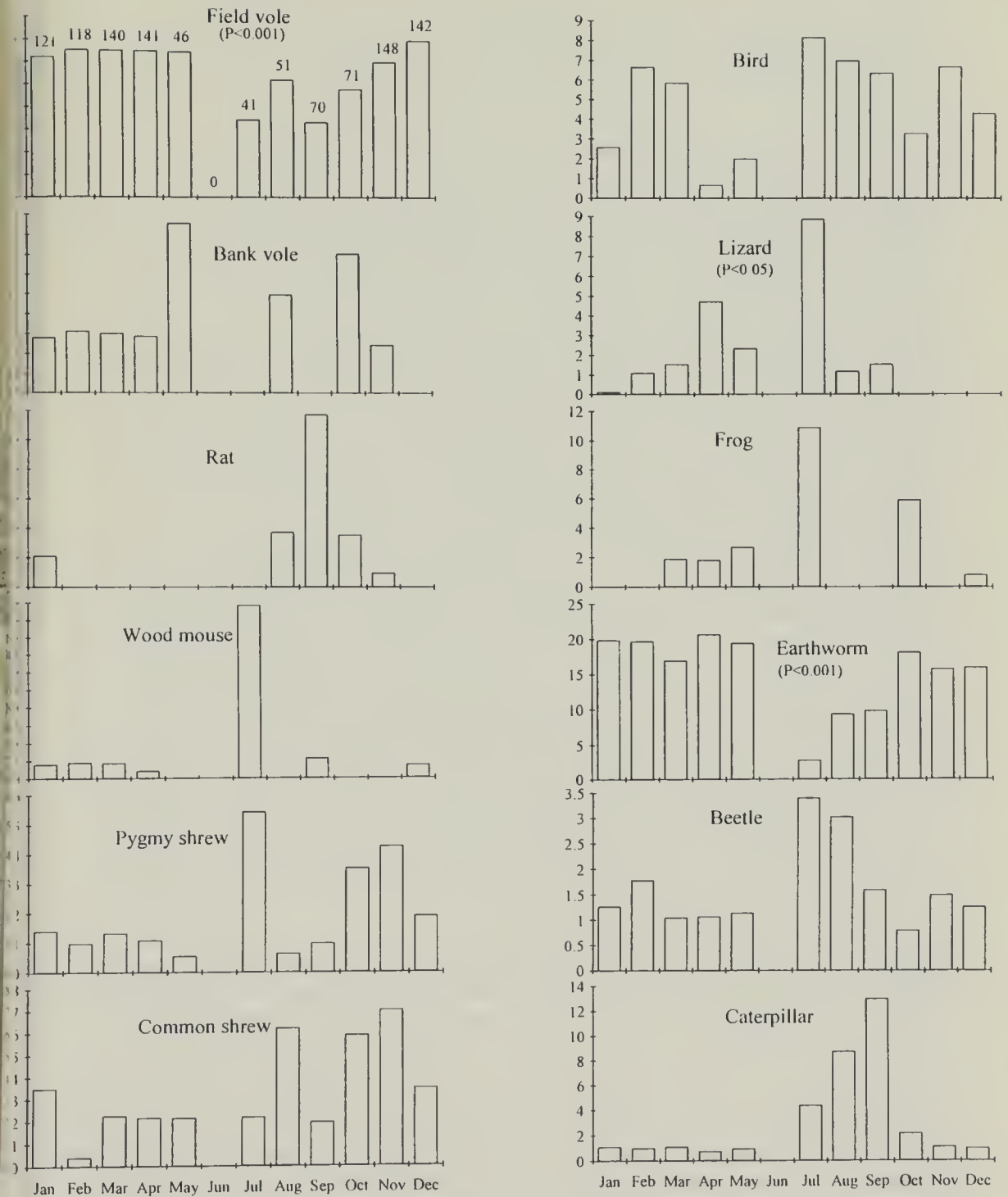


FIGURE 3

Prey/pellet by weight for each prey type, for each month, averaged over the four years of the study. Number of pellets analysed for each month is given at the top of each column of the field vole plot. P values refer to results of Pearson's Correlation analysis. All other results not significant.

DISCUSSION

Numbers of pellets collected

Male little owls are territorial throughout the year, and only a single pair is therefore likely to be found at a given site (Finck, 1990; Glue & Scott, 1980). The territory is often used throughout the life of a particular male. Little owls appear to be monogamous (Glue & Scott, 1980; Stamp, 1985), and pairs frequently stay together on the territory outside the breeding season (Mebs, 1966). The most striking observation therefore is that no pellets were found in June, when the owls are known to be nesting at the site. The number of pellets fell rapidly in the spring before rising again from July to the end of the year: can this be explained? The female will be at the nest from about mid-April since most egg laying in the little owl occurs between mid-April and mid-May (Glue & Scott, 1980; Wijnandts, 1984). The owls nest deep in a crack at the crag, and pellets will be dropped in this crack by the female during and immediately after incubation, since she rarely leaves the nest until the young are 10 days old. In June-August the male is fully occupied catching food for his mate and offspring (Finck, 1990). Roosting behaviour, and thus pellet deposition, may change during this time: e.g. the parents and young move around the territory together once the young leave the nest. By autumn, the males begin to drive the young out of the territory (Exo, 1988; Finck, 1990), and pre-breeding roosting patterns may return, explaining the rise in the number of pellets. Unless the female is resident throughout the year, most of the pellets are likely to be those of the male. Wijnandts (1984) also noted the difficulty of finding long-eared owl pellets during the breeding season, and we observe a similar pattern in the tawny owl (Julian & Altringham, 1994).

In the six months from November to April inclusive, the mean number of pellets found each month was 34 ± 3.5 ($n = 24$). Assuming the presence of a pair of birds, this is an average of 0.56 pellets/owl/day, or 1.12 if pellets are collected from only one owl. Hibbert-Ware (1938, p.178) notes that captive little owls produce 1-2 pellets/day, and Yalden and Morris (1990) state that owls typically produce 1-2 pellets/night. Wijnandts (1984) found that captive long-eared owls produce a minimum monthly mean of 1.2 pellets (average weight 1.78g) in May, and a maximum of 2.5 (0.85g) in November, resulting in little seasonal variation in total pellet weight. Assuming that two pellets per day are produced, we analysed between 28% (two owls) and 57% (one owl) of the pellets produced. From May to October (excluding June), a mean of 14 ± 3 ($n = 20$) pellets were found, an estimated 0.23-0.46 pellets/owl/day, and a minimum of 11.4 to 23% of the pellets produced. These values will be a little lower if the little owl produces night pellets: the long-eared owl produces an average of 28% of its pellet weight as night pellets, and many of these are dropped away from the roost. However, our sample should still be more than adequate to give a reliable representation of the owls' diet.

Mean prey weight per pellet was 20g; a single owl was therefore taking approximately 40g of food per day. This figure will be a minimum, since some allowance may need to be made for vertebrate prey which are digested and do not appear in the pellet: the real figure could therefore be up to 20% higher (see methods) or 48g. In a study by Lowe (1980) pellets from captive tawny owls weighed an average of 2.36g, and 19.5g of food were consumed to produce each pellet. Estimated mean prey weight/pellet from wild tawny owls was 30.3g (Julian & Altringham, 1994), perhaps due to the higher activity level of wild birds. The weight of food per pellet was thus similar to the 20-24g estimated for the little owl, despite the lower weight of the pellets (1.1g). However, the comparison should be made with caution: pellet size varies between wild and captive owls, and the relation with food intake is not straightforward (Wijnandts, 1984). The captive tawny owls in Lowe's study consumed 12% of their body weight in food per day, an average of 51g, and long-eared owls about 45g/day, or 16% body weight (Wijnandts, 1984). Little owls weigh about 170-190g (Cramp, 1985, p. 524) and a food intake of 40-48g = 21-28% body weight. Speakman (1991) estimated the resting metabolic rate of a little owl using methods described by Lasiewski and Dawson (1967), and the daily energy budget as determined for owls by Wijnandts (1984). Food requirements were then estimated by assuming that the

assimilation efficiency was 70%, the average energy content of the prey was 8.4kJ g^{-1} wet weight of meat (Ratcliffe, 1980), and the energy used was 3.1 times the resting metabolic rate. The result was an estimated food intake for a little owl of 45g/day to meet its daily energy requirements, a value very similar to our own, and to the observed intake of captive little owls (45g/day, Mikkola, 1983). The higher relative food intake of the little owl reflects its smaller size and higher mass specific metabolic rate, and possibly differences in activity patterns.

Field vole

Mammals constituted 72.4% of the diet by weight. By far the most important mammal was the field vole (61%, around 0.5 prey/pellet). Field voles were taken more frequently in winter and spring than in summer. A similar trend was reported by Ganya and Zubkov (1975) in Moldavia: 39% of the prey taken in the breeding season were rodents, and this increased to 71% outside the breeding season. This result is unlikely to be due to changes in vole abundance since their numbers are lowest in early spring, before breeding begins in March/April, and peak at the end of the breeding season in November (Webster, 1973), in populations which show annual cycles of abundance. One explanation for the low numbers taken in summer may be that voles are harder to catch in the long grass, heather and bracken, which provide more cover than at other times of the year, as suggested by Exo (1988, little owls) and by Southern (1954, tawny owls). Alternatively, voles may have been caught in similar numbers all the year round, but were fed to the offspring and did not appear in the adults' pellets in early summer. This is unlikely since the young have fewer mammals in their diet than adults (Glutz & Bauer, 1980; Mikkola, 1983). A third explanation is that other, seasonally abundant, prey were easier to catch, but this too is unlikely since no one prey item fulfills this role: a wide range of prey make up for the deficit left by the voles (see below). Finally, the little owls may have to compete with other species of owls: both long- and short-eared owls take field voles in large numbers over similar terrain (Yalden, 1985).

No correlation was found between the number of field voles and snow cover. During February 1991 when 70% of the month had snow cover and a maximum depth of 51cm was recorded, 20 field voles were found in 30 pellets: a higher than average number. Are the owls detecting voles in the snow, or are they exploiting patches of ground with little snow? In fact, snow cover was complete for very few days in any month, February 1991 excepted. Increased snow cover led to loss of weight and reduction of territory size in little owls in Germany (Finck, 1990); Shawyer (1987) observed that after 20 days of snow cover barn owls began to starve, and Wijnandts (1984) noted changes in diet in the long-eared owl with snow cover.

Field voles are known to undergo dramatic population oscillations at high latitudes, with peak numbers occurring every three to four years (Tapper, 1976). Many of their predators show similar oscillations which lag those of the vole (Lockie, 1955). Marchant *et al.* (1990) noted a 3-5 year cycle in little owl numbers in a nation-wide population survey in the U.K., but we found no evidence for such a cycle.

Although unlikely to be causally related, the strong correlation between field voles and earthworms is important, since together they make up 78% of the diet over the year. When the contributions from both decline in the summer, other prey items must be substituted. No other prey showed a negative correlation with either earthworms or voles, suggesting that no single prey type was being taken instead. When voles and worms are fewer, the owls presumably feed opportunistically, taking whatever is abundant or easily caught: rats, wood mice, birds and frogs all make their greatest contribution to the diet at some period during July to October (Fig. 3).

Other mammals

Mammals other than the field vole constitute almost 12% of the diet by weight. However, when fewer field voles were taken, other mammals occasionally became a significant

dietary component. Rats were rarely taken, but due to their relatively high body mass (60g), they were important from August to October (9-29% prey by weight, 0.05 prey/pellet). The owls may be exploiting young rats around buildings close to the crag: although size was not routinely estimated from skeletal remains, most were clearly from small animals. Territory size is approximately 40 ha in lowland England (Glue & Scott, 1980) and the home range (undefended foraging area) around it may be up to 500 ha (Mebis, 1966). Many nearby farm buildings could therefore be within the foraging area. Common and pygmy shrews were taken randomly in small numbers throughout the year (5% by weight, 0.05-0.2/pellet) despite being in greatest abundance June-August (Crowcroft, 1957; Yalden, 1974; Churchfield, in Corbet & Harris, 1993). Changes in the numbers of the two species were positively correlated, and both were probably found by chance when the owls were hunting for field voles. Wood mice were taken rarely: density may be low due to heavy grazing by sheep, since wood mice prefer habitats with good ground cover. Wood mouse were taken in larger numbers every July (17% by weight, 0.1/pellet), when densities are expected to be low (Flowerdew, 1985). When voles and earthworms are scarce, the owls may take advantage of the wood mouse's peak breeding season, when young are leaving the nest. Although July consistently yielded the highest wood mouse/pellet count, a very high count in 1992 is responsible for the very large peak in Fig. 3. Bank voles were rarely taken (consistently <5% by weight): this species, like the wood mouse, shows a strong preference for habitat with good ground cover.

Other vertebrates

Birds were taken in relatively small numbers and apparently randomly throughout the year (4.5% of diet by weight, 0.05-0.15 prey/pellet). Hibbert-Ware (1938) reported an increase in the number of birds taken during the breeding season but in this study the greatest numbers were taken in July to September, although the result was not statistically significant. Ganya and Zubkov (1975) reported a peak in birds taken during the autumn and winter. Little owls commonly live in, or close to, woodland where fledgling birds are available to them during the breeding season. The Eldwick Crag owls have limited woodland in which to hunt, and fewer birds, particularly fledglings, are likely to be available. In this study, small species were the most common prey: blue and great tit, goldcrest, chaffinch and meadow pipit. It is interesting to note that red grouse chicks are readily available, but there are no records of game chicks being taken. The correlation between the abundance of birds and beetles in the diet is unlikely to have any biological significance.

Lizards were taken more often than birds, but still make up only 1% of the diet due to their small size. Occasionally, they were taken in very large numbers (e.g. 18 in 41 pellets in April 1990, and 20 in 38 pellets in April 1991). The vast majority were taken between April and September, when they are most active. The few taken early in the year may not have been active, but found accidentally by owls foraging on the ground. Although no significant correlation between lizards and temperature was found, a significant seasonal difference was obtained by ANOVA: more lizards were taken in summer.

In most years small numbers of frog were first taken in March to May as the frogs come out of hibernation, and in two of the years many were taken in July, when frogs are most active, and again in October when they may be moving into hibernation.

Earthworms

Although the figure for earthworms of 17% of the diet by weight must be considered approximate, any errors are unlikely to shift it from its position as the second most important food source. A similar result was reported by Yalden (1985) for tawny owls. Their contribution to the diet drops significantly over the summer months. Warm, dry weather causes earthworms to go deeper into the soil to avoid desiccation, and to find softer soil. The negative correlation between earthworms/pellet and temperature is therefore not unexpected, although very cold weather is also likely to drive worms deeper

into the soil. The positive correlation between rainfall and earthworms taken was not quite significant at the 5% level, but it is tempting to suggest that the low number of earthworms taken in the summer is due in large part to hard, dry surface soil.

Other invertebrates

The number of beetles taken was typically 1-2 per pellet, and occasionally 3 in late summer, when the owls were presumably exploiting a local abundance. Surprisingly, there was no correlation between numbers of beetles taken and temperature, and ANOVA detected no seasonal trends. Indeed, in the exceptionally cold month of February 1991 for example, an average number of beetles was taken. This implies that the owls were taking dormant, in addition to active, beetles. The species most commonly taken include: *Thanatophilus rugosus*, *Bembidion* species, *Pterostichus madidus*, *Pterostichus niger*, *Calathus fuscipes*, *Nicrophorus vespilloides*, *Staphylinus aeneocephalus*, *Geotrupes stercorarius*, *Geotrupes spiniger* and *Aphodius rufipes*. The smallest of these species are taken most frequently.

Caterpillars are taken throughout the year in small numbers, but as expected more are taken from July-October, when the average of <0.5/pellet rises to 1-3/pellet. The caterpillars are probably those of noctuid moths. As with beetles, those taken in winter are presumably dormant.

Comparison with other studies of the little owl in Europe

Previous studies generally record only the number of prey taken, and do not assign a weight to each prey item, often leading to false indications of the relative importance of different prey. The absence of prey weights means that comparison can only be approximate. For example, the Eldwick Crag little owls are thought to be taking mostly the smallest beetle species, weighing about 0.25g. In the study by Hibbert-Ware (1938), larger species (1g) such as dung beetles (*Geotrupes*) and cockchafers (*Melolontha*) were abundant in pellets. Furthermore, few studies appear to have identified earthworms in pellets: this may be real or due to incomplete analysis.

Studies of British little owls by Collinge (1924) and Hibbert-Ware (1938), are in broad agreement with our own as far as prey types are concerned, but the results cannot be quantitatively compared in any detail. Collinge expresses data (from stomach contents) as % bulk, but does not define the term. Insects constituted 53% of the diet, mammals 20%, earthworms 14% and birds 5%. Small numbers of frogs were also found. Mammals were more common in winter (51% of owls examined) than in summer (19%) in agreement with this study and that by Ganya and Zubkov (1975). Interestingly, wood mice were the most commonly taken mammal (in 68% of stomachs examined), presumably reflecting the wooded farmland habitat of the little owls in the study. Pellet analysis by Collinge (1924) gives % bulk values as 54% mammals and 41% insects. This difference between results from pellets and stomachs could suggest differential digestion of prey, but the samples were small and from different localities. In Hibbert-Ware's study (1938) mammals were taken in varying quantities throughout the year, and when available, they became almost the sole constituent of the diet: brown rats, wood mouse, field vole, bank vole, house mouse (*Mus musculus*) and rabbit (*Oryctolagus cuniculus*). Insectivores eaten were common shrew, mole (*Talpa europea*) and the occasional bat (*Chiroptera*). The first mole turned up in pellets from our little owls in 1993. Hibbert-Ware noted frogs (*Rana temporaria*) as an occasional prey item, as in this study, and lizards (*Lacerta vivipara*) occurred at two sites.

Many species of birds were noted in the diet by Hibbert-Ware (1938) but starlings, house-sparrows, blackbirds, and song-thrushes were taken in the greatest numbers. The predominant species taken by the Eldwick Crag little owls were blue-tit, great-tit, chaffinch, goldcrest and meadow-pipit. This difference in bird prey is presumably a reflection of the different habitats in the two studies: Hibbert-Ware's sites were almost exclusively lowland agricultural. Collinge (1924) found only starling and house sparrow in any numbers in the stomachs examined.

Mikkola (1983), and Brooks (in Cramp, 1985) summarised data collected in the rest of Europe, but results are expressed as % total number of prey. Few clear geographic or seasonal patterns can be seen in the data. Mammals ranged from 2-51% of prey taken, and were inversely related to the number of invertebrates (98-46%). Birds, reptiles and amphibians combined were never more than 2.8%, and less important than they were to our owls. Earthworms were important, particularly in the north, but no values were given. For comparison, mammals were 26% by number in our study, earthworms 22%, other invertebrates 48%, and other vertebrates 5%: within the ranges observed for the rest of Europe. The number of voles taken (field, 18.3%; bank, 0.6%) was at the upper limit for the rest of Europe (all voles, 1-21%). Mikkola (1983) suggests that invertebrates become more important from mid-Europe (72% of prey by number) towards the Mediterranean (98%), as vole populations decline (Herrera and Hiraldo, 1976). In line with this trend, invertebrates were far less important to our more northerly owls (60%).

Comparison of the diet with that of other species of owl in Britain

Yalden (1985) studied four species of owl in the north of England, about 60 km south of our site. Mammals constituted the following percentages by weight of their diet: tawny (53%), long-eared (68%), short-eared (84%) and barn owl (99%). In all cases, the field vole was by far the most important single prey species (24, 52, 68 and 70% of diet respectively). Petty (1992) recorded 78% field vole by weight in tawny owl pellets in Northumberland. Mammals constituted 72.4% of the diet of the little owls in our study (61% field voles), higher than for tawny and long-eared owls in Yalden's study. It should be noted that our results (and others?) overestimate the annual average vole intake, since more pellets are found in winter, and these contain more field voles.

The finding that voles and other small mammals are the major food of these little owls, a result contrary to popular belief, prompts an interesting question: if these individuals are typical of little owls, is this introduced species a possible competitor of Britain's native owl species? There are an estimated 6,000-12,000 pairs of little owls in the U.K (Gibbons *et al.*, 1993), more than short-eared (1,000-3,500), long-eared (2,200-7,200) and barn (5,000) owls. The best estimate currently available for tawny owls is "over 20,000" (Gibbons *et al.*, 1993). According to Gibbons *et al.* (1993), all species have declined over the last two decades, the little and tawny owls by 11%, the short-eared, long-eared and barn owls by 15, 25 and 38% respectively. No reliable census data exist to indicate whether the earlier rise in little owl populations was accompanied by a decline in other species.

Is there anything in the distribution, habitat and diet of these owls to suggest that competition is possible? All show major overlap in their distribution, with the exception of the little and short-eared owls: the former is confined almost exclusively to England, the latter has its stronghold in upland Britain. Where they do overlap, competition is a possibility. As stated in the introduction, the little owl is thought of as a lowland bird, and thus an unlikely competitor to the short-eared owl, a predominantly upland species. However, records in West Yorkshire present a different picture. Little owls were recently recorded in 73 of the 1,357 one km squares, only 8 (11%) were below 150m, and 42 (58%) were above 250m. Little owls were found in five of the 22 squares occupied by short-eared owls. Short-eared owls habitually hunt over open moorland (Yalden, 1985) and take similar proportions of voles and total mammals (68 and 84% respectively by weight) to little owls (61% and 72% respectively). In lowland habitats, competition is possible with barn, long-eared and tawny owls. Mikkola (1983) suggests that the little owl avoids competition with the tawny owl by being more common in open habitats and less strictly nocturnal, but notes that it does hunt and nest in barn owl habitat. Gluc and Scott (1980) found little owl and barn owl nesting in the same tree. Three local little owl sites known to the authors have resident tawny owls, and a fourth a barn owl. The patchy distribution of the long-eared owl has been attributed to competition with the tawny owl, which has increased over the last 100 years (Sharrock, 1976; Lack, 1986). However, Yalden (1985) has shown that there are major differences in their diets, and suggests that the long-eared

owl hunts over moorland far more than previously thought. When the long-eared owl does use woodland, it occupies plantations of a different age structure to the tawny owl (Petty, 1985; 1992). There is considerable overlap in the diets of little and long-eared owls (61 and 51% field voles; 72 and 68% total mammals, respectively: this study and Yalden, 1985), despite their different hunting strategies, and little owls could therefore be in competition with long-eared owls. The barn owls in Yalden's study (1985), in habitat similar to our own, ate 70% field voles and 99% total small mammals. Resident little owls could significantly affect the prey availability of such a specialist species. No direct evidence for competition is available, but we think that the theory justifies further investigation.

The results presented create a picture of these little owls as opportunistic feeders with a strong bias towards mammalian prey. It would be interesting to know how representative they are of the species. The large number of mammals taken in the snow, and the beetles, lizards and caterpillars taken when presumably inactive in cold weather, suggest that these little owls frequently use a ground hunting strategy. Mikkola (1983) describes the little owl as a more terrestrial hunter than other owls, and likens it to the similarly long-legged American burrowing owl (Voous, 1960).

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CHANGES IN THE DISTRIBUTION OF REPTILES IN THE EAST RIDING OF YORKSHIRE

BARRY R. KIRK

3 Kingsmead, Woodmansey, North Humberside HU17 0TF

INTRODUCTION

Little work has been carried out on the distribution of reptiles in East Yorkshire. The only work to identify any change in their distribution is that of Howes (1989) on the adder in Yorkshire which identified a decline in its distribution in East Yorkshire using 1970 as a time boundary. Apart from this work, there is little evidence to indicate whether reptile species in the area have undergone any change in the last hundred years. In view of habitat changes in East Yorkshire, such as urban expansion, intensification of agriculture, loss of semi natural habitats, increased access to the countryside and afforestation, it would be expected that changes in distribution of some reptile species would have occurred. The hypothesis here examined is that at least some of the four species considered will have undergone distribution pattern shifts over the last hundred years.

REPTILES OF EAST YORKSHIRE

Of the six terrestrial reptiles found in mainland Britain, four have been recorded in East Yorkshire according to the national distribution maps produced by the Institute of Terrestrial Ecology. These are: adder *Vipera berus* (Linnaeus, 1758), grass snake *Natrix natrix* (Linnaeus, 1758), common lizard *Lacerta vivipara* Jacquin, 1787 and slowworm *Anguis fragilis* Linnaeus, 1758. Copies of these distribution maps are reproduced in Frazer (1983) with updates for adder in Stafford (1987) and common lizard and slowworm in Stafford (1989). Reports of the sand lizard *Lacerta agilis* Linnaeus, 1758 in the area were investigated and largely discounted by Kirk (1989). There is no evidence that the smooth snake *Coronella austriaca* Laurenti, 1768, the other British reptile, has ever occurred in any but a few southern counties of England.

STUDY AREA

As most records encountered in the literature were on a vice county basis, it was decided to use East Yorkshire (vice county 61) for the study as opposed to using any current administrative area. The study area consists of three major regions: the majority of the Yorkshire Wolds, Holderness and areas of the Vales of York and Pickering.

Holderness lies to the east of the area and is bordered to the north and west by the Wolds. It is an area of boulder clay with scattered glacial gravel deposits. Originally an area of marsh and mere, extensive draining was already completed by the late nineteenth century (Sheppard 1958). A large number of drainage ditches today run through the area. Holderness is a rich agricultural area, the majority of the land being grade two agricultural land. Many areas are characterised by large arable fields, the result of agricultural intensification.

The Wolds are an area of rolling chalk hills forming a semi-circular band from the Humber Estuary to the west of Hull to the North Sea coast just north of Bridlington. Much of this area was sheepwalk until the nineteenth century. Today it is intensively farmed arable land and areas of unimproved grassland are rare.

The Vales of York and Pickering are characterised by sandy soils and, in the south, former fen land. These areas lie to the west and north of the Wolds respectively. The Vale of York was once a landscape of wet heaths, marshes and commons. Today much of this area has been drained and the commons either ploughed out or afforested; only a remnant of these areas remains. Only a small area of the Vale of Pickering is contained in the study area.

METHOD

To test the hypothesis it was necessary to obtain data to determine the distribution of each

species at points over time. In order to obtain past records of reptiles a series of sources containing references to the natural history of the East Riding of Yorkshire were searched. Of major importance to this study were the publications of the Yorkshire Naturalists' Union. It was possible to examine a full run of *The Naturalist* from its first publication in 1875 to the date of the study (1992); the field notes and field trip reports contained in the publication have been of particular use.

From 1913 to 1973 the YNU published annual reports, the majority of which were printed in *The Naturalist*. These usually included reports of the Vertebrate Section which often contained a summary of the reptile records, together with comments, received for the year of the annual report. All annual reports were examined for this study and proved a very important source of records.

Since its inception the Union has arranged an annual field trip to East Yorkshire, the reports of which were published in *The Naturalist* and occasionally contained reptile records. A series of fly sheets advertising these field trips occasionally contained information on reptiles known to occur in the area to be visited. A number of these circulars were examined which produced several records dating mainly from the period 1890 to 1940. Since 1984 the Union has published a twice yearly *Bulletin* and a few further records were obtained from this source.

The Hull Natural History Society (formerly the Hull Scientific and Field Naturalist Club) produced the *Transactions of the Hull Scientific and Field Naturalist Club* between 1898 and 1906; between 1961 and 1977 a *Bulletin* was issued. Some reptile records appeared in these sources. The Hull Natural History Society kept records of non-avian vertebrates for the period 1962 to 1988. The only other natural history society that has been active in the area, and from which records were obtained, was the South Holderness Countryside Society. Founded in the mid-1970s, it is presently very active and provided a number of useful records for the Holderness area.

When the Yorkshire Naturalists' Union stopped producing an annual report in 1974 an important source of records was lost, although field trip reports have continued to be included in the YNU's publications. In order to obtain records between that period and the present day, details of records from a number of local naturalists were solicited. The majority of the records collected in this manner dated from the period 1980 to 1992.

The records collected were sorted by species and date and a note made of any comments relating to habitat type, status or other relevant information. It is proposed to make a detailed analysis of these comments the subject of later papers. The location of the record was recorded at kilometre square level. Failing that, the record was located to the nearest tetrad (2km x 2km). The data collected were plotted on maps at the tetrad level. The tetrad was chosen as it allowed records which contained only basic location details, for example only a village name, to be used.

RESULTS

From the various sources investigated, a total of 174 records were obtained of which 161 were locatable at tetrad level. The records collected for each species were divided into twenty year time bands back from 1992. This divided the records into the following groups by date: 1893 to 1912, 1913 to 1932, 1933 to 1952, 1953 to 1972 and 1973 to 1992. Table 1 shows a breakdown of the references by species and by time. Ideally a shorter time period of ten years would have been useful. Unfortunately, the number of records collected would have made such a short timescale difficult to analyse. A further group, for records before 1893, was also used. The records collected were translated into a series of maps at tetrad level showing location of records by each 20-year period. The tetrad maps were also converted into a coarser 10km square grid. This follows the procedure used by Jefferies *et al.* (1989) and allowed localised observer effort to be filtered out. For the purposes of this paper, the records at tetrad level collected are reproduced as single maps for each species (Maps 1 to 4). Each map shows the records collected for each species over the period 1973 to 1992 and also pre-1973 records in tetrads for which no

TABLE 1
Breakdown of reptile references by species and time period.

	Pre 1893	1893-1912	1913-1932	1933-1952	1953-1972	1973-1992
<i>Adder</i>						
<i>All records</i>	3	6	4	2	5	5
<i>No. of tetrads*</i>	3	4	3	1	2	1
<i>Grass Snake</i>						
<i>All records</i>	0	5	4	21	19	31
<i>No. of tetrads*</i>	0	4	1	12	13	23
<i>Common Lizard</i>						
<i>All records</i>	4	8	3	12	13	15
<i>No. of tetrads*</i>	4	6	3	6	7	10
<i>Slowworm</i>						
<i>All records</i>	0	3	2	2	2	4
<i>No. of tetrads*</i>	0	3	2	1	1	2
<i>All references</i>						
<i>Total</i>	7	22	13	38	39	55
<i>No. which could be located to tetrad level</i>	7	22	11	32	36	54

* No. of different tetrads per time period.

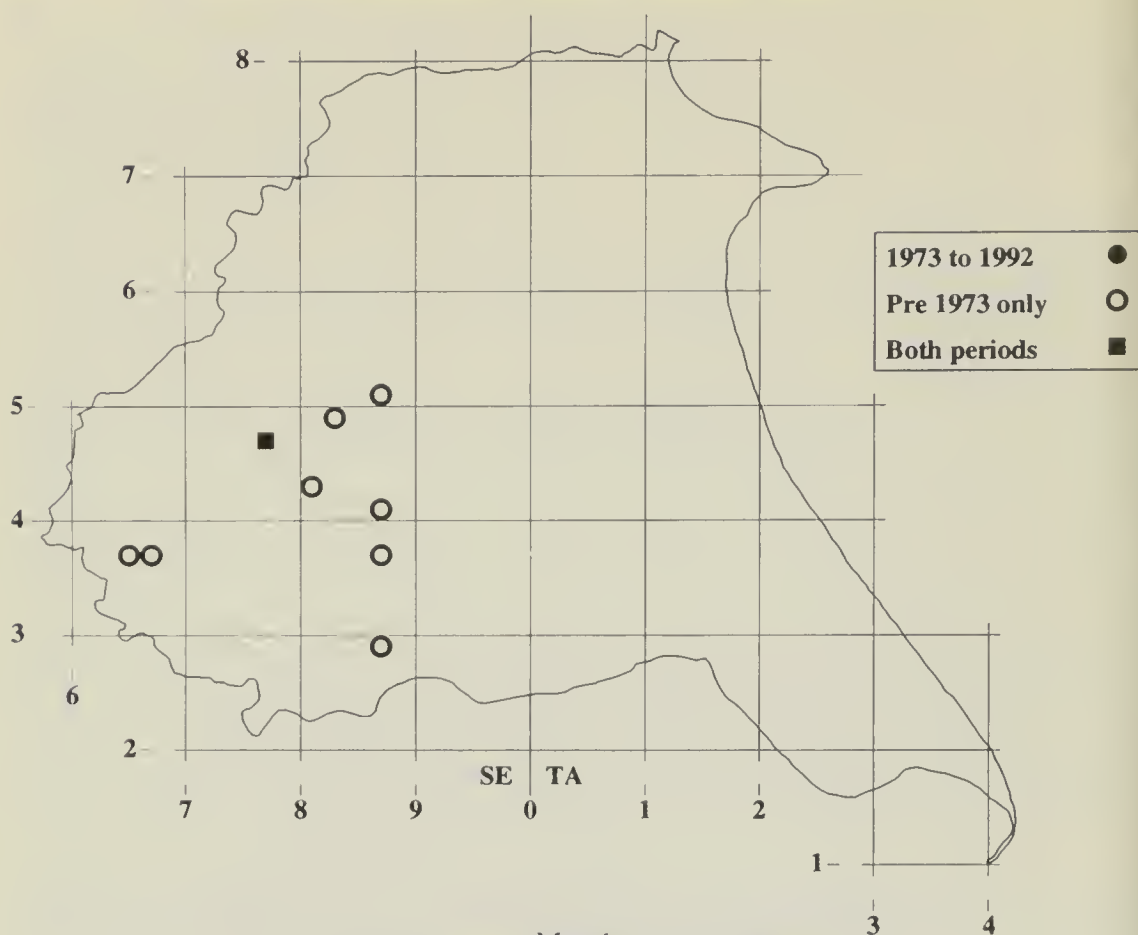
TABLE 2
Number of reptile records per time period at 10km² level

	Pre 1893	1893-1912	1913-1932	1933-1952	1953-1972	1973-1992
<i>Adder</i>	2	3	2	1	2	1
<i>Grass Snake</i>	0	3	1	10	10	12
<i>Common Lizard</i>	2	6	3	3	6	5
<i>Slowworm</i>	0	1	1	1	1	2

record exists in the later period. A breakdown of the records to 10km square level is contained in Table 2.

Adder

Twenty-five records, all locatable, were found during data collection. Although the number of references has remained steady, the number of locations per 20 year period has fallen over time from four in 1893-1912 to only one in the last 20 years. Today only Allerthorpe Common appears to hold a population of adders in East Yorkshire. The habitat of the adder was strongly associated with heath, this being the habitat type for the majority of records in East Yorkshire. Records for heath sites include Skipworth, Allerthorpe and Riccall Commons. There is no evidence to suggest that the species occurred anywhere in East Yorkshire other than in the Vale of York except for two nineteenth century records from the Wolds. The adder does inhabit chalk grasslands in southern England and these early references show that it once occurred on the Wolds. These populations appear to have disappeared by the turn of the century, probably as a result of the conversion of grass land to arable land during the nineteenth century, and the adder has been restricted to the Vale of York since then.



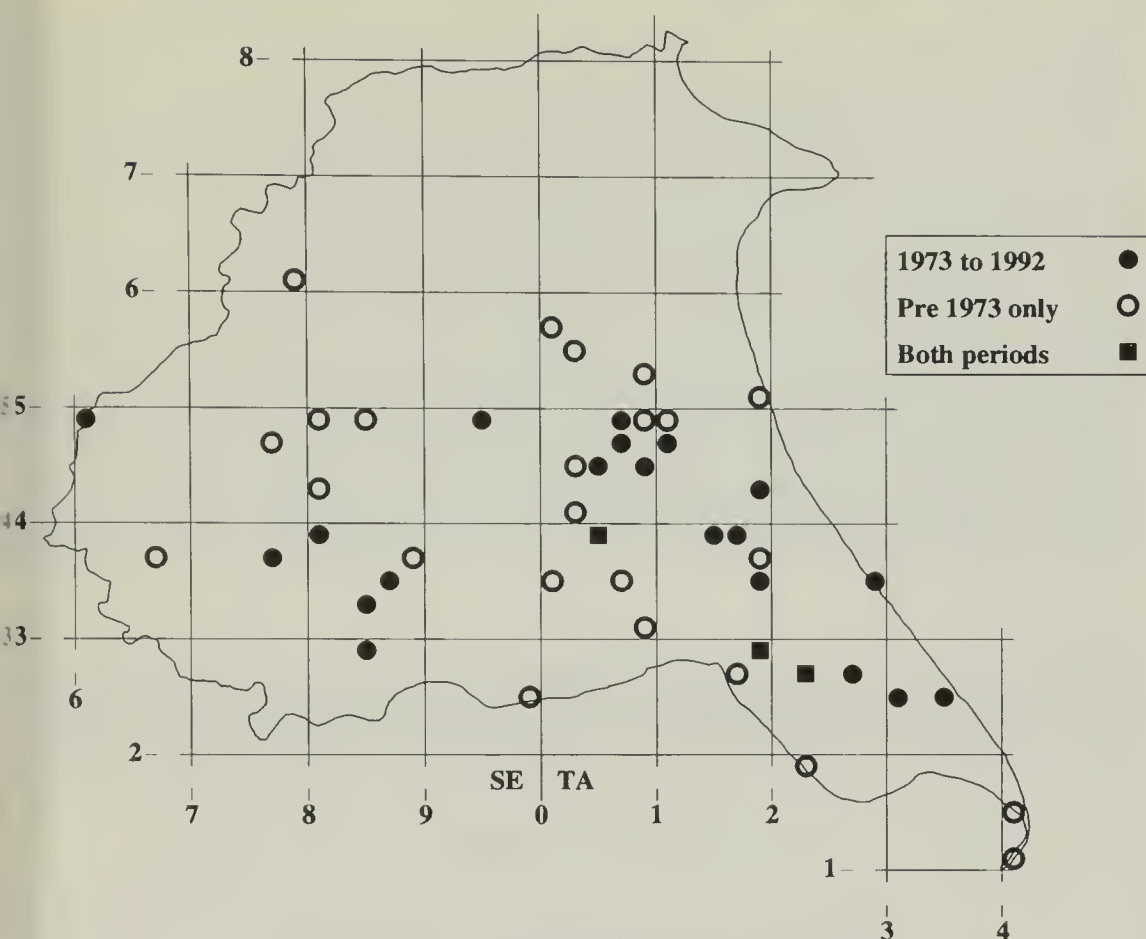
Map 1
Distribution of the adder in East Yorkshire.

Grass snake

Of the four species studied the largest number of records found related to the grass snake. However, few pre-1930 records were located. The majority of records occurred after that date with a slight increase in numbers in the last 20-year period. In total 81 references produced 72 locatable records to 48 different tetrads.

When considered at 10km square scale, the pattern of the few early records and a number of later ones was maintained. The later three 20-year periods produced a total of occupied squares of 10, 10, 12 respectively. The use of a coarser scale such as a 10km grid is regarded as countering local observer effect. This analysis tends to support the tetrad-based results, i.e. that the number of grass snake records has held steady over the last 60 years. However, the tetrad map indicates that the number of locations recorded pre-1972 in central and western parts of the county have not been supported by recent records and clusters of records in the south-west of the county are not represented by pre-1972 records.

As discussed earlier, the source of records used in this study comprised two types: those collected from the literature and those solicited from local naturalists. The majority of records from natural history society sources occurred in the last 20 to 30-year period. These records have tended in the past to be passed to the Yorkshire Naturalists' Union and published in its annual report; this was confirmed in a number of cases where individual records obtained from the annual reports were repeated when natural history society records were searched. In such cases only the first was used, but this tended to confirm that most society reptile records did find their way into the literature. The YNU annual report ceased being published in 1973. Records taken from natural history society sources after that date can, therefore, be regarded as a continuation of those that would have appeared in



Map 2
Distribution of the grass snake in East Yorkshire.

the annual report and hence a continuity is maintained.

Few solicited records referred to the adder or slowworm and only a very small number to the common lizard. The effects of these few records was not felt to be significant on the analysis work for these species. In the case of the grass snake a considerable number of solicited records were obtained. In the last 20-year period, no fewer than 13 of the 31 references collected fell into that category. To test the effects these might be having on the analysis, these records were removed. The number of locations in the period 1973 to 1992 fell from 23 to 16. A reduction of three locatable records was also experienced in the period 1933 to 1952. This would adjust the final three 20-year period sequence from 12-13-23 to 9-13-16. This new sequence is less suggestive of a rapid rise in location numbers over the last 20-year period than the old sequence.

The number of tetrads occupied has remained relatively constant since the nineteen thirties. The grass snake was found to be associated with a number of different habitat types. It occurs today at a number of locations in the Vale of York, particularly in and around locations in the Walling Fen area. However, its current stronghold remains in Holderness. A number of reports from Holderness are associated with former gravel workings, such as at Brandesburton, Burstwick and Haverfield.

The dearth of records in the earlier periods of the study is more difficult to explain. There is a small amount of evidence in the collected data to suggest that observers in the twenties and thirties regarded this as a genuine increase, which would have coincided with a climatically warm period which may have aided the incubation of eggs of this species. The other three species considered all give birth to live young.

Common lizard

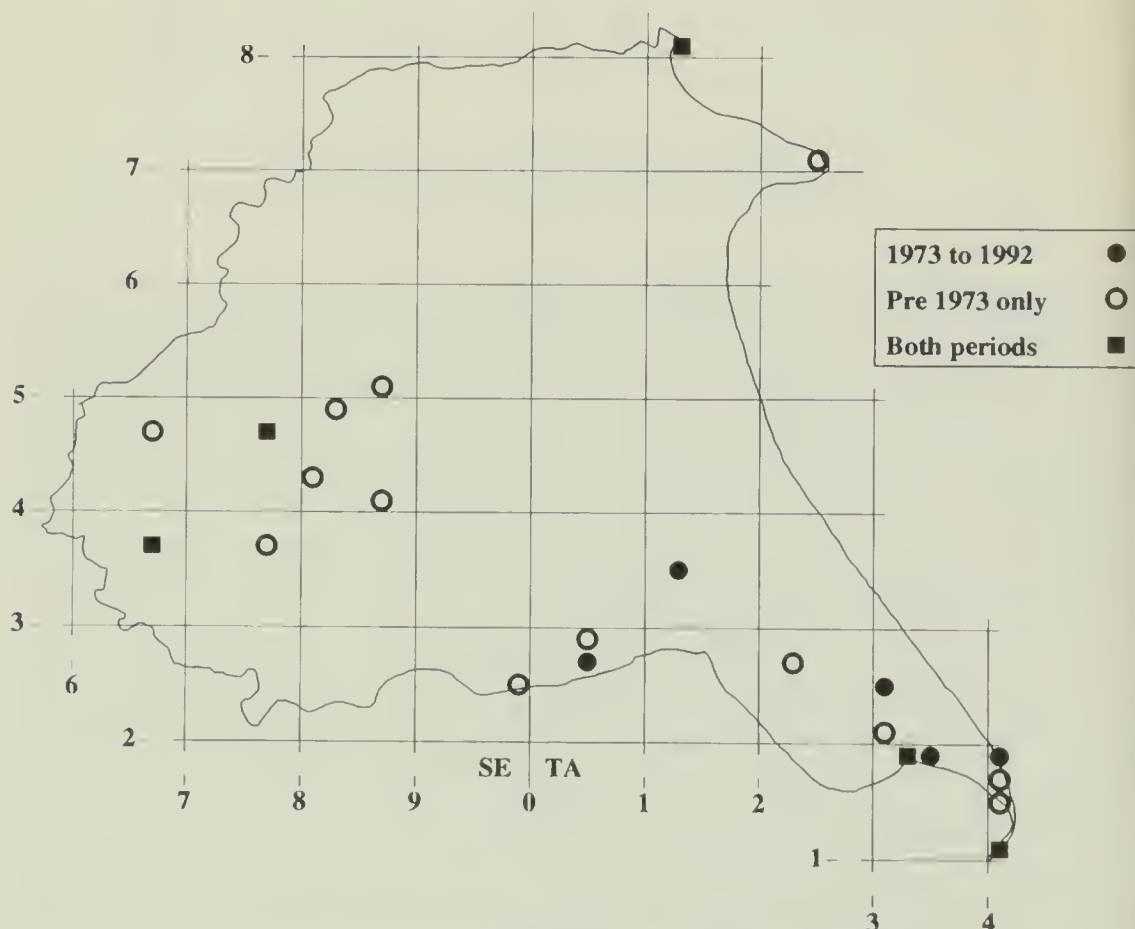
Fifty-five references to the common lizard, of which 53 were locatable, covering 24 individual tetrads were found in the data search. Concentrations of records were found in South Holderness, particularly close to the estuary and southern parts of the coastline. Spurn Point has been a consistent source of records. A number of records relating to sandy areas of the Vale of York were also found. Two early records dating from 1885 were discovered relating to the Wolds, but no records have been found for this century. A wide range of habitat types were found to be associated with the common lizard.

The number of records for the common lizard over the study period has remained constant. There has been little change over the last three 20-year periods in the number of references found but a slight increase in number of locations was noted. Relatively constant numbers of 10km squares have been shown to be occupied during the whole study period.

Analysis of the data collected suggests that a decline in range of the species in the Vale of York has occurred. Apart from this the pattern of records and their spread appears to have remained similar throughout. As the common lizard is a well camouflaged and quick moving species it is likely to be considerably under recorded. It also appears able to survive in habitats disturbed by human activity. The common lizard's future would seem secure in East Yorkshire.

Slowworm

Only a small number of records have been found of the slowworm in East Yorkshire. This may be due, in part, to the secretive nature of the animal. A maximum of three locatable references per 20 year period have been recorded. The level of records has remained very



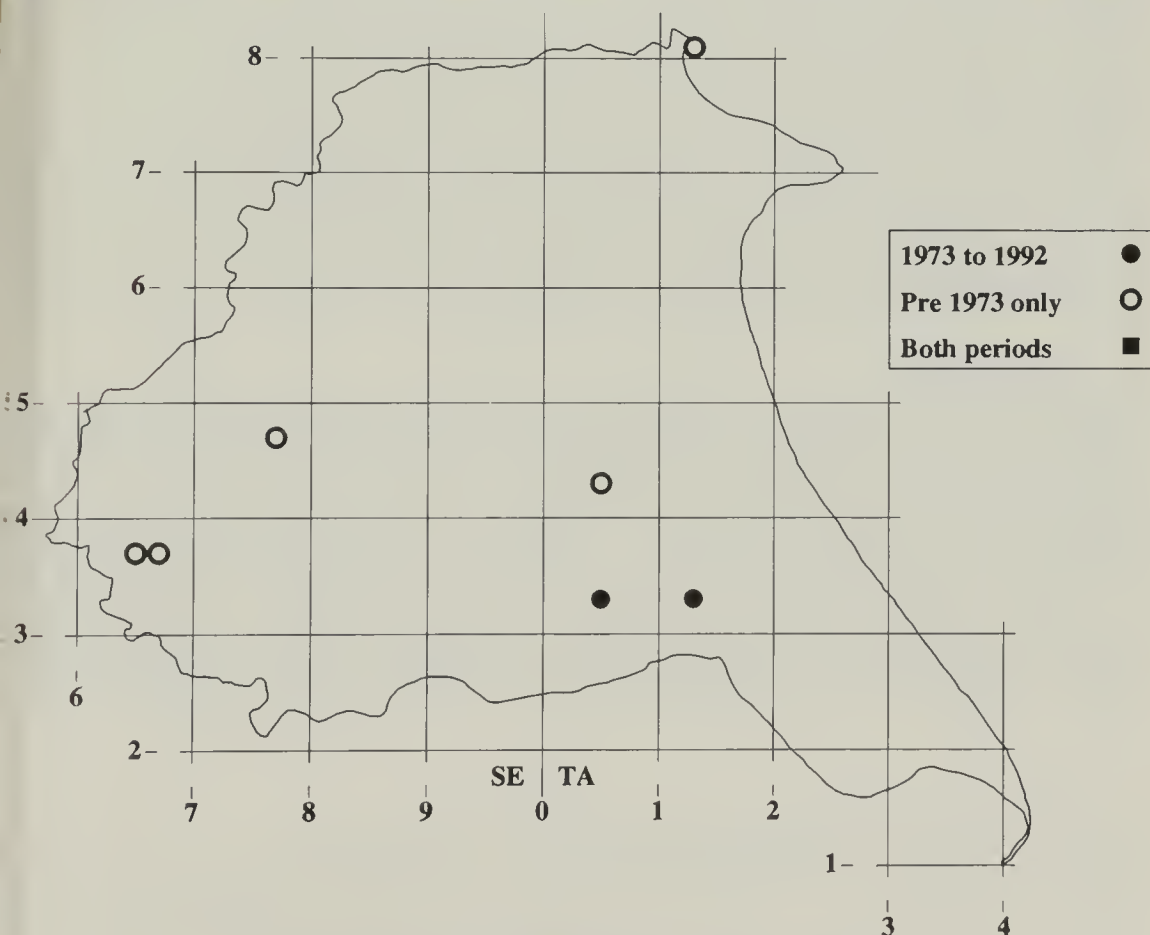
low throughout the study period and it is possible to split these records, with the exception of an early coastal record at Filey, into two groups.

The first group are a small number of records from the heaths on the Vale of York. All these records date from early this century. The second group relates to a small group of records in the 1960s and 1970s from the urban fringe of the city of Hull. It has in the past been suggested that reptile records very close to major conurbations result from the escape of pets. The time of these records would coincide with a period of growing interest in unusual pets and of little legal restriction on the sale of native reptiles. It was not possible to determine whether these urban fringe records represent viable populations or just individual animals.

During data collection a note was made of all references to optimistic and pessimistic statements encountered relating to reptiles. Pessimistic words found included declining, extinct, rare, uncommon and habitat destroyed. Optimistic words were common, abundant, numerous, static, many, increasing, viable and plentiful. The ratio of optimistic words to pessimistic words for all the time periods were as follows; adder 3:2, common lizard 10:1, grass snake 10:7 and slowworm 0:1. These results can be said to broadly support the results obtained in the earlier analysis.

DISCUSSION

The aim of this work was to find patterns over time in the distribution of reptiles in the East Riding of Yorkshire. The only way to determine the past distribution of vertebrates such as reptiles is by reference to natural history literature. This method has been used satisfactorily for a number of species in Britain. Work by Jefferies *et al.* (1989) highlighted



Map 4
Distribution of the slowworm in East Yorkshire.

a number of shortcomings in this method but found it, in the case of their study, reliable. These shortcomings were associated with factors such as observer effort and a tendency to report new localities only.

Some increase in the number of references found over time did occur in the study. It is possible that this increase in records reflected an increase in observer effort. However, by undertaking a coarse scale assessment using a 10km² grid it was possible, to a degree, to assess observer effort effects. The problem of a tendency to report only new localities is thought less likely to influence the results in this study, than in one on more commonly seen species than reptiles. The sighting of a reptile in East Yorkshire is nearly always a rare enough event to be worthy of comment by naturalists.

Undoubtedly, the method employed here has weaknesses. However, unless a large untapped source of references is discovered at some time in the future, the records collected represent the only means of examining past distribution. The work carried out provides the most detailed analysis of reptile distribution in the area to date and the results obtained present the best tool available by which to consider reptile conservation.

It should be noted that few records were obtained for the northern most part of the study area. It has not been possible to determine whether this reflects a genuine absence of reptiles or whether a lack of recorder effort is indicated.

CONCLUSIONS

The hypothesis presented in this work, that in the study area the distribution of reptiles would have been expected to change over the last hundred years in line with land use changes, has been proved. The distribution of the adder has been reduced considerably over the study period and this appears to be due to the loss of heathland habitats. That of the slowworm appears to have shifted from heathland habitats to urban areas. The decline in the range of the adder determined from the data is confirmed by a number of contemporary references relating to its decline in the literature searched. The distribution of the grass snake and common lizard has been shown to be relatively stable over the study period although some evidence of range contraction was noted for both species. However, the data collected also suggested an increase in the range of the grass snake earlier this century. There is, however, no strong evidence in the literature examined from the early part of the century to suggest that this species was regarded as rare at that time and this apparent increase in range may represent an anomaly in the data.

ACKNOWLEDGEMENTS

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DEER IN THE SHEFFIELD REGION INCLUDING THE EASTERN PEAK DISTRICT

ANDREW J. MCCARTHY AND IAN D. ROTHERHAM

Sheffield City Ecology Unit, City Museum, Weston Park, Sheffield S10 2TP

ABSTRACT

An evaluation of the status of deer in the Sheffield area was undertaken in response to suspected increases in the region's four species. The survey was based upon data from existing records, literature review, questionnaires and interviews with field workers. Results indicated population changes in all species. Fallow and red deer populations were most stable whilst roe deer and muntjac appear to have increased their ranges considerably and are now colonising the region's urban fringe. The conservation and management implications of these changes are discussed in the light of major new woodland initiatives.

INTRODUCTION

During recent decades deer populations in many parts of the country have increased considerably and in some areas as many as four species may be present in a single woodland (Chapman *et al.*, 1993). In southern England, for example, muntjac (*Muntiacus reevesi*), have expanded their range very rapidly in recent years and are now familiar visitors to suburban gardens, whilst the spread of roe deer (*Capreolus capreolus*) throughout mainland Britain during the last century is well documented (Prior, 1968).

The effects of deer on forestry, conservation and agricultural interests may be severe. High densities of such large herbivores may cause considerable damage in a woodland understorey, affecting tree regeneration and the relative abundance of woodland field layer species (Anon., 1977; Putman, 1988).

Information received by the Sheffield Environmental Records Centre and the Sorby Natural History Society indicates that this region may be experiencing an increase in deer numbers. Since the publication of the last report on deer in the Sheffield area (Whiteley & Clinging, 1980), there has been no systematic examination of the records or evaluation of the present situation. This is now particularly relevant given the magnitude of deer management problems experienced elsewhere in the country. With the recent development of the South Yorkshire Forest promoting management of existing woodland and establishing new planting, an assessment of the status of deer is urgently required. The Sheffield City Ecology Unit (SCEU) in collaboration with the Sorby Natural History Society and the Hallamshire Branch of the Deer Society, launched a study of deer in the region in Spring 1993. This has the primary intention of establishing base line data against which to evaluate future trends.

METHOD

The survey area broadly corresponds to that studied by the Sorby Natural History Society (See Figures 1-4) and stretches from the M62 near Huddersfield to the northern boundaries of Derby and Nottingham, and from Doncaster and Sherwood to the central Pennines (a total of c. 4200 km²). A variety of methods were used to gather information. In addition to a literature review and examination of data from biological records centres at the museums of Rotherham, Sheffield and Derby, useful information was obtained from a questionnaire.

This was circulated to interested members of the public via the local media, and to the memberships of the two collaborating organisations. Requests for information were also sent to parishes within the region, to organisations such as local police forces (who frequently have an interest in wildlife matters) and to individuals with whom SCEU and the collaborating partners have regular contact. These included land owners, gamekeepers, farmers and local deer stalkers. Records received were, wherever possible, evaluated by checking with the recorder, by field visits to the site concerned, or by cross-checking with other recorders from the same area. Vague or unconfirmed reports were omitted from the analysis.

RESULTS

Red Deer (*Cervus elaphus* L). (Figure 1).

Park Herds The region has supported red deer in emparked and feral populations since at least the medieval period (Whiteley & Clinging, 1980). Of the park herds described by Whitaker (1892), several are still extant, of which the best known are at Chatsworth in Derbyshire, which has approximately 40 animals, and Wentworth Woodhouse in South Yorkshire, which has a herd of around 100. Other smaller, emparked herds are present within the region, including those in the Sherwood estates of Welbeck and Thoresby (both with around 20 animals). Other captive herds include one at Beauchief Hall in south-west Sheffield (around 30 animals) and at least one deer farm to the south-west of Barnsley near Dodworth.

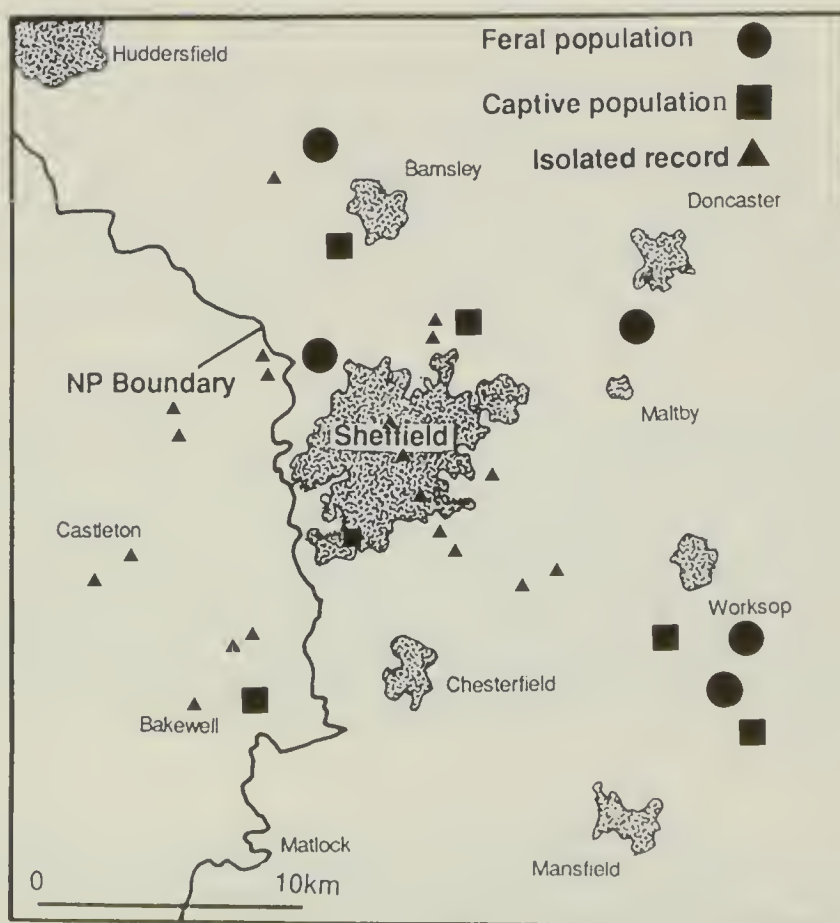


FIGURE 1
Distribution of red deer (*Cervus elaphus*) in the Sheffield Region

Feral Herds Several feral herds are present in the region, the majority of which probably originated as escapees from park or other captive herds. The best documented is at Wharncliffe, north-west of Sheffield. These animals are probably descendants of the original herd on Wharncliffe Chase and are known to range widely throughout the Wharncliffe area, through Bitholmes Wood and the Ewden Valley, west as far as the eastern moorland fringe of the Peak District National Park. Isolated individuals, probably originating from this herd, have been recorded dispersing as far west as Bradfield Moors and as far south along the Don Valley as Kelham Island in the centre of Sheffield. Recent reports have suggested that the number of animals may have declined during the 1990s as a result of persecution in the Ewden Valley (S. Ellis; P. Leadbeater, *pers. comm.*), and information from the Sheffield Environmental Records Centre suggests that a dozen or so animals were present in the area during the early 1980s. Reports from local farmers and others suggest rather higher numbers, and culls were carried out in Bitholmes Wood in the late 1980s.

Several other feral herds are present in the region although none are large. Sherwood forest has a population of feral red deer which are probably from the original stock of the Welbeck estate. The Clumber Park region supports around 40 animals which range through the woodlands of Sherwood as far south as Thoresby. Other small herds present in the survey area include one in woodland south-west of Doncaster, where up to six animals have been recorded together, and one to the west of Barnsley, near Deffa Wood.

Isolated Sightings There have been reports of individual red deer from throughout the study area, except in urban Huddersfield and Chesterfield, and in the predominantly agricultural land to the east of Sheffield, between Sherwood and Doncaster. These may be dispersing individuals from feral herds or escapees from captivity. Several records are from the moorlands, in particular Big Moor, Bamford Moor and Shatton Moor. These are probably escapees from the Chatsworth estate, although they may be individuals moving east from the Goyt Valley in the western Peak District, or even escapees from Lyme Park. There have been several records of individual animals, presumably escapes, around Wentworth Woodhouse north of Rotherham. During the 1990s, six records came from the southern fringe of Sheffield around the Rother, Moss and Gleadless valleys. These animals are thought to have originated from the captive population at Beauchief.

Fallow deer (*Dama dama* L.) (Figure 2).

Fallow are present in the region in both feral and emparked herds. Several large park herds remain, the largest being at Chatsworth and Welbeck, each with around 200 animals. A smaller captive herd, of around 35 animals, is present at Thoresby, south of Welbeck.

Feral Herds There are several long-established feral populations within the study area. Most of these probably descended from Thoresby or Welbeck stock, or from park herds now no longer in existence. In Sherwood, large herds are distributed throughout the area and range from the Welbeck and Clumber estates in the north (where a white variety is present), as far south as the Nottingham urban fringe. Fallow range freely throughout this area and are considered a serious pest in forestry plantations. Populations are probably high, with as many as several hundred individuals being sighted together on occasions (P. Dare, *pers. comm.*).

Other feral populations include a herd in the woodlands around Darley Dale, to the west of Matlock. These include a number of melanistic animals and are almost certainly the descendants of the original Stanton Hall herd, a variety reputedly imported from Norway around 1800 (Whitaker, 1892). Up to 30 animals have been reported from the area in the past although the present population or trend is unknown. A visit by one of the authors during 1993 indicated that the population remains high, with numerous tracks and paths present throughout the area. A dwindling fallow population remains in the area around

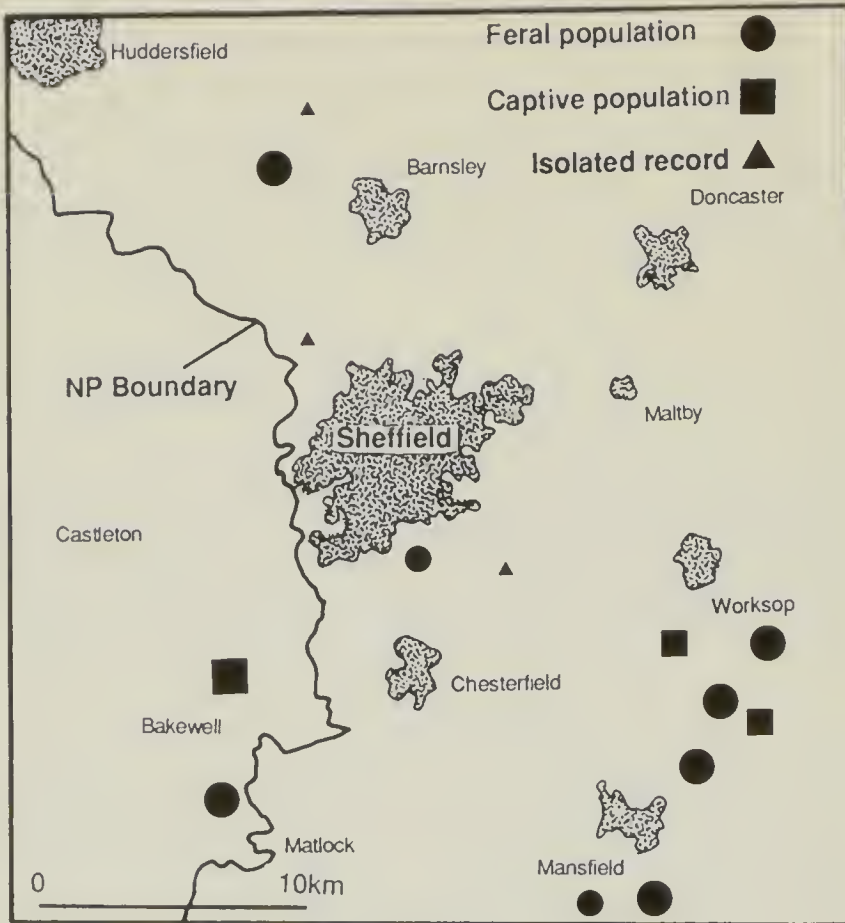


FIGURE 2
Distribution of fallow deer (*Dama dama*) in the Sheffield Region.

High Hoyland near Deffer Wood, to the west of Barnsley. This population probably originated from the remnants of the park herd at Canon Hall. During the 1950s and 1960s the population was perhaps around 30 animals; however, in recent years persecution has probably reduced the herd's size to under ten (G. Carr, *pers. comm.*). Recent reports indicate that a small number of fallow may have become established in woodland between Dronfield and Sheffield. These may be escapees from a small captive herd near Eckington.

Sika deer (*Cervus nippon* Temminck)

There were no reports of sika in the study area. The red herd in the High Hoyland woodlands may have been the source of an erroneous record of sika which was received by the Sorby Natural History Society recorder in the 1960s. This was published in the Sorby Record (Clinging & Whiteley, 1980) and has formed the basis for most subsequent published information pertaining to sika in the region (e.g. Mitchell, 1985; Corbet & Southern, 1977). Marjory Wood near Huddersfield was reputed to hold a few individuals during the 1970s; however, this could not be confirmed and no subsequent records have been forthcoming.

Roe deer (*Capreolus capreolus* L.) (Figure 3)

Recent records of roe indicate that this species may have expanded its range considerably

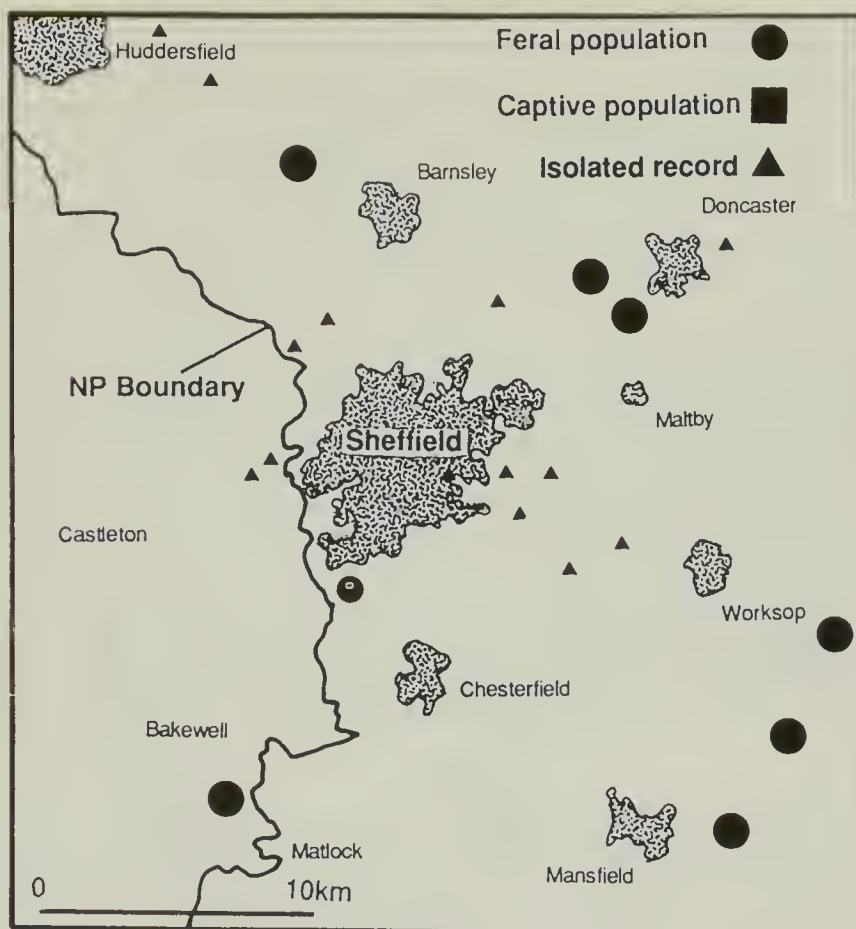


FIGURE 3

Distribution of roe deer (*Capreolus capreolus*) in the Sheffield Region.

during the past decade; it is now firmly established on the fringes of the region and apparently expanding inward. Prior to this, records were few and mostly restricted to the Doncaster area, which was probably colonised during the 1960s from strongholds in North Yorkshire (Howes, 1977).

Since this time, roe appear to have successfully spread south-west of Doncaster and to wooded areas to the south-east of Huddersfield. Scattered records have also been received from the eastern side of Sheffield, although few were forthcoming from the area to the north of Worksop, where poaching is known to be severe (P. Firth, *pers. comm.*). A number of records were received from south-eastern Sheffield, with some indicating that individual roe have penetrated into the urban area beyond Woodhouse. To the south-east of Sheffield, roe seem to be becoming established in Sherwood despite vigorous control by commercial foresters. East of Sherwood, in the Elkesley area, population densities are sufficiently high to constitute a serious problem in commercial plantations (P. Dare, *pers. comm.*). On the western side of Sheffield recent records have been received from the high moors around Snake Pass (D. Gerrard, *pers. comm.*); Totley Moor (N. Smith, *pers. comm.*), the Limb Valley (J. B. Shaw, *pers. comm.*), and from the Ewden Valley (N. Dyson, *pers. comm.*). Roe may also be present in Wharncliffe, with tracks being recorded from the northern end of Wharncliffe woods during 1993 by A. Warren (*pers. comm.*). Further south, roe are apparently well-established in woodlands around Darley Dale and Matlock. Whilst there are no records in support of movement to the Sheffield urban area from this region, the relatively wooded nature of the landscape around Chatsworth would make passage via this route possible.

Muntjac (*Muntiacus reevesi* Ogilby) (Figure 4)

Prior to 1980, records of this species were restricted to a single individual which was reported barking in the Froggatt area, and several sightings near Derby. Muntjac are known to have been established for some years in southern Sherwood around Annesley Woodhouse.

During the 1980s the situation appears to have changed considerably. Muntjac now appear to be firmly established around Doncaster, and on the southern fringe of Sheffield and the species is now becoming established throughout the Sherwood area (P. Darè, *pers. comm.*).

Five confirmed sightings were reported from southern Sheffield during the course of the survey, including several animals sighted by one of the authors at Charnock in the Moss Valley. Other reliable records include a captured animal at Dronfield Sewage Works during 1989 and several sightings in woodland to the north of Eckington. Tracks and runs have been reported by Deer Society members in woodland south of Dronfield (McCarthy & Rotherham, *in press*). The population in Doncaster appears centred on the wooded Doncaster Common (Howes, 1993).

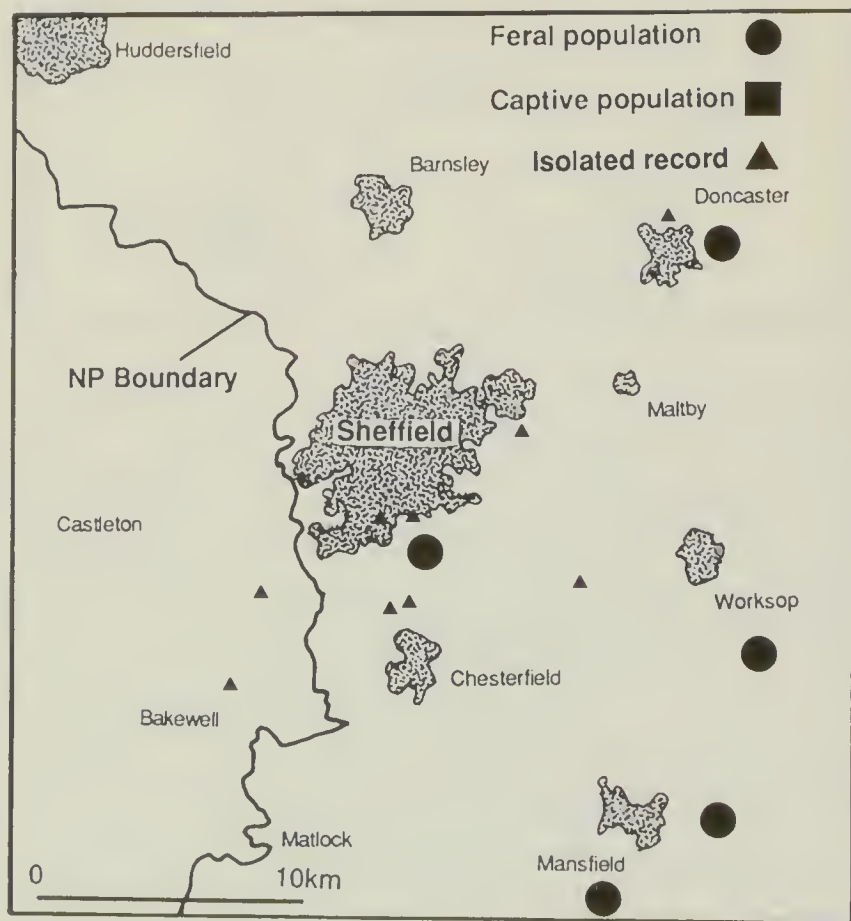


FIGURE 4

Distribution of muntjac (*Muntiacus reevesi*) in the Sheffield Region.

DISCUSSION

It seems clear that the region has experienced some changes in its deer population since the last review in 1980. With the possible exception of Wharncliffe, long established feral populations of red and fallow seem to have either remained static or have declined. A

number of previously unknown populations have been confirmed, such as those south-west of Doncaster and to the south of Sheffield. By contrast, roe and muntjac appear rather more successful, extending their ranges from the fringes of the region to the edge of the main urban areas. The success of muntjac remains something of an enigma. Natural colonisation rates of muntjac are rather slow (Chapman *et al.*, 1993), and it seems unlikely that the species has been able to spread into the Doncaster and Sheffield areas without human assistance. Indeed, accidental or deliberate release is now considered to be the principal mechanism of the species' countrywide spread (N. Chapman, *pers. comm.*). Both muntjac and roe appear to be spreading slowly through Sherwood, although feral deer species are heavily controlled in this area.

The records suggest that deer populations in the region are rather localised. Of particular note is the paucity of records for certain areas, such as between Sherwood and Doncaster, and west of Sherwood toward Bolsover. According to local police and members of the Deer Society, poaching is particularly severe in these areas and this may account for the lack of records. An additional contributory factor may be the highly fragmented nature of suitable woodland habitat, although roe deer are known to occur at very high densities in agricultural landscapes in Central Europe (Zejda & Homolka, 1980). Not surprisingly, deer populations are concentrated in areas of greatest woodland cover such as in the Sherwood and Wharmcliffe areas. Few records were received, however, from wooded 'corridor' habitats such as the Derwent Valley south of Matlock, the Derwent valley around Grindleford, or the well-wooded landscape around Silkstone Common, to the east of Barnsley. This may reflect a paucity of records from these areas, however, rather than a genuine absence of deer.

MANAGEMENT CONSIDERATIONS

The implications of increasing deer populations may be of importance for conservation management in the region. Recent work on muntjac at Monks Wood National Nature Reserve in Cambridgeshire has indicated damage to woodlands by selective feeding on field layer and understorey species. Early results indicate that damage to species such as bluebell or orchids may be locally very high and that muntjac feeding patterns may have long-term implications for woodland structure, with young hazel coppice being browsed and replaced by birch (Cooke & Farrell, 1993). Similarly, roe can pose considerable problems in woodland managed for conservation or forestry and may cause severe damage in coppiced or newly planted areas (Putman, 1988).

Increasing deer populations may have long term implications for the management of new forestry initiatives in the area. This is especially relevant given the recent establishment of the South Yorkshire Community Forest, for which extensive new woodland planting is planned over a 40 year period. The Forest covers some 394 square kilometres, and extends in an approximately triangular area from Stocksbridge in the north-west to Dearne in the north-east, and south to Eckington and Gleadless in Sheffield (SYF, 1993). There are several established deer populations already located within the forest area and on its margins. These include both roe and muntjac which may expand their range and numbers given the increasingly wooded nature of the Sheffield urban fringe. These population changes may ultimately require potentially expensive management practices such as deer fencing and sapling protection and there may be calls for culling if populations reach high densities, particularly since a proportion of the forest is expected to be new commercial plantation. This may result in something of a conflict, since in the Sheffield area at least, both roe and red deer are regarded as 'Local Red Data Book' species (Bownes *et al.*, 1991).

A REQUEST FOR INFORMATION

The authors would like to stress that the survey is on-going and they would be grateful for any additional information regarding deer in the region.

ACKNOWLEDGEMENTS

Thanks are due to the various Deer Society members who have remained so enthusiastic

during the course of the survey, in particular Paul Leadbeater, Steve Ellis and Anna Sykes. We are also grateful to all those who have provided information or who have assisted the survey, including Paul Dare (Dukeries Deer Management), Nick Moyes (Derbyshire Biological Records Centre), Derek Whiteley (Sheffield City Museum and Sorby Natural History Society) and Val Clinging (Sorby Natural History Society).

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GROUND BEETLES (COLEOPTERA, CARABIDAE) FROM A GARDEN AND A SMALL FIELD

K. G. PAYNE

15 Broad Lane, Cawood, Selby YO8 0SQ

INTRODUCTION

During 1989 and 1990 pitfall trapping was used to estimate the number of species of carabid beetle occurring in a small garden and an adjacent field at Cawood in the Selby area. A total of 72 species was recorded, including three species considered to be scarce or threatened nationally. With four additional species taken by various collecting methods during 1991-1994, this makes a total of 76 species, which is about 30% of the species recorded from Yorkshire and about 20% of the British species.

This work may provide further evidence that collecting in small private gardens and pieces of undeveloped land may yield results of some interest. Strong evidence for this has been provided by Jennifer Owen's well documented study of her Leicester garden (Owen, 1991). She points out that the total area covered by gardens in Britain is probably over 485,000 ha. and is increasing year by year. This area is over three times that covered by National Nature Reserves and nearly 20 times the holdings of the 46 county naturalists trusts (Perring, 1987). Since the gardens are distributed among about 15 million owners, there is a wide diversity of management policy and resulting habitats.

Probably many entomologists have kept lists of species taken in their own gardens but surprisingly few such lists seem to have been published. It is hoped that this account may encourage other people to carry out intensive collecting in their own gardens or in other small areas of land. Perhaps it is particularly to be recommended to ageing entomologists!

THE STUDY AREA

The area is in VC64, centred at about SE576374 and within the village of Cawood, 6km. north-west of Selby. It comprises a garden of 630m² and a 1.18 ha. field adjoining it.

The garden is rectangular in shape and is bordered by Leyland cypress hedges on its two long sides and a low hawthorn hedge on the road-side in front; it is open to the field behind. Over two-thirds is grass, cut with a lawn-mower, and the rest comprises two "mixed flower" borders, a few shrubs and an apple tree about 3.5m. high. There is a mature oak tree about 12m. high and with a spread of about 15m. growing within the garden at its north-east corner.

The field is mainly grass and most of it is cut for hay annually. It has not been ploughed in the last 20 years but must have been at some time in the past as part shows a ridge and furrow pattern. The wetter parts of the area are in depressions up to about 0.75m. deep relative to the rest of the field. These depressions are the remains of a moat and a fish pond associated with the medieval manor of Keesbury. They lie within an area of about 0.19 ha. and most of the pitfall traps in the field were within this area. There is some *Phalaris arundinacea* L., *Epilobium hirsutum* L., *Lythrum salicaria* L. and *Juncus effusus* L., but no truly aquatic vegetation. Gardens, some with Leyland cypress hedges, border the field on two sides, a new housing estate on one and a sports field on the other.

METHODS

The traps were plastic cream cartons, 64mm. diameter at the top tapering to 42mm. at the bottom and 72mm. deep. They were "planted" with the rims at soil level, using a garden bulb-planting tool; no steps were taken to exclude rain. No doubt some beetles managed to climb out, as on several occasions upward-climbing specimens were seen approaching the top. Possibly the fact that only one specimen of *Demetrias atricapillus* (L.) and only one of a *Dromus* sp. were trapped resulted from the climbing abilities of these species.

On about 20 occasions traps were found to have been pulled out of the ground by magpies, but it is not known whether they, or other birds, ate insects from the traps. 10

traps were sited in the garden and 10 in the field. The former were either in mown grass or in the flower borders which were kept (more or less) weeded and so did not become deeply overgrown. No attempt was made to keep the vegetation from growing about the traps in the field, as to do so is quite time consuming and, by late June, some traps were in vegetation 300mm. deep.

As far as possible, all traps were kept in constant positions throughout the two-year survey period. However, winter flooding forced progressive moving of some of the field traps to higher ground. As the water level dropped again they were returned progressively to the bottoms of those hollows which had proved to be the most productive of carabid beetles.

No bait was used in the traps and a killing and preserving liquid only when the writer was away from home for long weekends and holidays (about 30 days per year). Four percent formalin was tried but soon replaced by 25% ethylene glycol ("antifreeze"), which left specimens completely relaxed. For the remaining 22 months of the survey the catch was removed from the traps daily, the smaller species with a pooter. The dry catch was far more pleasant to examine than the mushy mixture of carabids with other insects, spiders, woodlice, slugs and worms in ethylene glycol.

At least one and usually two or more voucher specimens of all species taken were kept. Apart from this, as many specimens as possible were determined alive, the smaller ones in plastic boxes on the stage of a stereomicroscope, and returned to the field or garden. Those needing more detailed examination were killed with ethyl acetate, and specimens made as necessary.

Trapping was carried out for two complete years, from February 1989 till February 1991. Regular trapping was then discontinued. For convenience, the catches are attributed to the calendar years 1989 and 1990.

Consideration was given as to what extent the catch of carabids had suffered from allowing vegetation to grow long around half the traps, since the consensus of opinion in the literature seems to be that the best catches are obtained by keeping the areas about traps free of vegetation (Thiele, 1977). A comparison was therefore made with the catches recorded in four published accounts of pitfall studies (Fishpool & Usher, 1989; Greenslade, 1963; Luff & Davies, 1972; Walker, 1985). The average monthly catch of each of the Cawood traps was 8.35 carabids compared, after correcting for different trap diameters, with a mean of 10.6 for the four published studies. Since two of the four studies were carried out entirely during summer and early autumn when catches predictably are higher than in winter, a higher mean is probably to be expected. It may be significant, though, that the highest yield per trap, 17.0, was in a study in which an area 0.5m. diameter about each trap was cleared of vegetation and litter (Greenslade, 1963).

RESULTS

The pitfall trapping yielded a total of 4,025 specimens of Carabidae, 2,072 in 1989 and 1,953 in 1990. The species taken are listed in Table 1, with their numbers recorded during the two years.

Trechus discus (F.), *Bembidion clarki* Dawson and *Acupalpus consputus* (DuRoi.) are listed as "Notable B" in the J.N.C.C. list of scarce or threatened Coleoptera.

15 species were taken in 1989 but not in 1990, and seven in 1990 but not in 1989. The value of continued trapping over two years rather than one is therefore clear.

The value of a long continued trapping programme is shown far more clearly, though, by Owen's Malaise trapping of hoverflies in her Leicester garden. Over 15 years 91 species were taken and these represent about 36 % of the species recognised as British. However, the maximum number of species taken in any one year was 62 and the minimum in any one year 37. New species were added in 13 out of the 15 years (Owen, 1991).

As is well known in pitfall trapping studies, the numbers of particular species trapped cannot be taken to indicate their abundance in the study area because these numbers depend upon the activity of the species as well as upon the numbers present. The number

trapped is often referred to as the "activity density". The activity of a species depends, among other things, upon the readiness with which it can traverse the vegetation of the area, that is, overcome the "environmental resistance" (Thiele, 1977). However, during the present study, the traps were kept in substantially the same positions throughout the two years and, as far as is known, no significant changes of vegetation cover took place as between the same months of 1989 and 1990. It therefore seems that, as stated by Owen regarding her pitfall traps, (Owen, 1991) the number of a species trapped in different years does indicate its relative abundance in those years. Regarding those species recorded only

TABLE 1
Pitfall trap catches.

1989 1990				1989 1990			
<i>Cyrchus caraboides</i> (L.)		2	G	<i>Pterostichus niger</i> (Schaller)	162	21	FG
<i>Carabus nemoralis</i> Mueller	11	4	FG	<i>P. nigrita</i> (agg.)	419	384	FG
<i>Leistus ferrugineus</i> (L.)	36	39	FG	<i>P. strenuus</i> (Panzer)	34	69	FG
<i>L. fulvibarbis</i> Dejean		1	F	<i>P. vernalis</i> (Panzer)	10	5	F
<i>L. rufescens</i> (F.)	1		F	<i>Abax parallelepipedus</i> (P. & M.)	15	3	FG
<i>Nebria brevicollis</i> (F.)	178	76	FG	<i>Calathus fuscipes</i> (Goeze)		1	F
<i>Notiophilus biguttatus</i> (F.)	25	11	FG	<i>C. melanocephalus</i> (L.)	8	10	FG
<i>N. germinyi</i> Fauvel	1		F	<i>C. piceus</i> (Marsham)	1	4	FG
<i>Elaphrus cupreus</i> Duft	2	1	F	<i>Synuchus nivalis</i> (Panzer)	6	2	FG
<i>E. riparius</i> (L.)	2		F	<i>Agonum albipes</i> (F.)	1		G
<i>Loricera pilicornis</i> (F.)	174	43	FG	<i>A. dorsale</i> (Pont.)	1		F
<i>Clivina fossor</i> (L.)	16	25	FG	<i>A. moestum</i> (Dufts.)	4		F
<i>Patrobus atrorufus</i> (Stroem)	68	12	FG	<i>A. muelleri</i> (Herbst)	2	5	FG
<i>Trechus obtusus</i> Erichson	137	459	FG	<i>A. thoreyi</i> Dejean	1	5	F
<i>T. discus</i> (F.)	3	1	FG	<i>Amara aenea</i> (Degeer)	29	82	FG
<i>T. micros</i> (Herbst)	1		F	<i>A. apricaria</i> (Paykull)		1	G
<i>T. quadristiatus</i> (Schrank)	>7	1*	FG	<i>A. aulica</i> (Panzer)	2		FG
<i>Asaphidion curtum</i> (Heydon)	1*		G	<i>A. bifrons</i> (Gyll)	8	17	FG
<i>A. flavipes</i> (L.)	>1		G	<i>A. familiaris</i> (Dufts.)	10	12	FG
<i>Bembidion aeneum</i> Germar	42	48	FG	<i>A. lunicollis</i> Schiodte	226	227	FG
<i>B. biguttatum</i> (F.)	5	11	F	<i>A. ovata</i> (F.)	1		F
<i>B. clarki</i> Dawson	20	51	F	<i>A. plebeja</i> (Gyll.)	2	2	FG
<i>B. doris</i> (Panzer)	12	9	F	<i>A. similata</i> (Gyll.)		2	FG
<i>B. guttula</i> (F.)	20	58	FG	<i>Harpalus rufipes</i> (Degeer)	8	5	FG
<i>B. harpaloides</i> Serville		1	G	<i>H. rufibarbis</i> (F.)	4	1	FG
<i>B. lampros</i> (Herbst)	46	21	FG	<i>Trichocellus placidus</i> (Gyll.)	1	3	F
<i>B. lunulatum</i> (Fourcroy)		1	G	<i>Bradycellus harpalinus</i> Serville	3	5	F
<i>B. obtusum</i> Serville	2		F	<i>B. ruficollis</i> (Stephens)		1	F
<i>B. properans</i> Stephens	4	4	FG	<i>B. verbasci</i> (Dufts)	1	1	FG
<i>B. quadrimaculatum</i> (L.)	7	2	FG	<i>Stenolophus mixtus</i> (Herbst)	2		F
<i>B. tetracolum</i> Say	97	52	FG	<i>Acupalpus consputus</i> (Dufts)	1	2	F
<i>Stomis puniceatus</i> (Panzer)	1	1	FG	<i>A. dorsalis</i> (F.)	1		F
<i>Pterostichus diligens</i> (Sturm)	9	28	FG	<i>A. dubius</i> Schilsky	2	1	F
<i>P. gracilis</i> (Dejean)	1		F	<i>Demetrius atricapillus</i> (L.)	1		F
<i>P. madidus</i> (F.)	63	35	FG	<i>Dromius linearis</i> (Olivier)	1		F
<i>P. melanarius</i> (Illiger)	88	61	FG				
<i>P. minor</i> (Gyll.)	22	24	F				

"F" indicates species taken in the field

"G" indicates species taken in the garden

*1 or more.

once or a very few times, though, it is obvious that chance played a big part in determining whether they were, or were not, recorded in a particular year.

Four species additional to those obtained by pitfall trapping in 1989-1990 have since been obtained in the garden. These are *Badister bipustulatus* (F.) and *Notiophilus rufipes* Curtis from pitfall traps and *Dromius melanocephalus* Dejean and *Dromius quadrimaculatus* (L.) by "beating". In addition, *Bembidion harpaloides* Serville and *Bradycellus harpalinus* Serville, previously only taken in the field, have since occurred in pitfall traps in the garden. These take the total of species found in the garden to 51.

Most of the species taken, are, not unexpectedly, common and widespread. Of the remainder, beside the three J.N.C.C. list species, *Bembidion doris* (Panzer), *B. aeneum* Germar, *Synuchus nivalis* Panzer, *Amara bifrons* (Gyll.), *Stenolophus mixtus* (Herbst) and *Aculpalpus dubius* (Schilsky) are uncommon though widely distributed (Mr J. H. Flint in litt 24-10-89).

NOTES ON PARTICULAR SPECIES

Six specimens of *Asaphidion flavipes* (agg.) were taken, all from two traps sited within 200mm. of the house walls. Three of these were determined by Mr M. L. Denton and two proved to be *A. flavipes* (L.) and the other *A. curtum* (Heyden). Three more specimens of *A. flavipes* (agg.) were taken in the same traps in 1992. There therefore seems to be a possibility that from 1989 till 1992 small numbers of the two species were living against the house wall. However, Mr D. G. Hemmingway has pointed out that *Asaphidion* species are highly mobile and individuals may have flown from a distance, collided with the house wall and fallen to its base.

A single specimen of *Bradycellus ruficollis* (Stevens) occurred, 3-9-90. It is interesting to speculate as to whether it had come from Skipworth Common, 7km. away, or from a garden in which some heathers are grown adjoining the field. Regarding the latter possibility, it was taken in a garden in Blackheath many years ago and thought likely to have originated from heathers in a nearby garden (Allen, 1978).

Cychnus caraboides (L.) was taken only once when a male and a female were found in cop. in a trap in the garden.

With 803 specimens taken, *Pterostichus nigrita* (agg.) was the most numerous species in the traps. Dissection to separate these into *P. nigrita* (Payhull) and *P. rhaeticus* Heer, recently shown to occur in Britain (Luff, 1990), was considered quite impracticable. The species here recorded must therefore be considered as the aggregate.

It was found that a *Trechus* with highly reduced wings was very common in the traps. The only practicable measure was to assume that these (596 specimens) were all *Trechus obtusus* Erichson, though specimens of *Trechus quadristriatus* (Schrank) with reduced wings are known in continental Europe (Lindroth, 1974). 19 *Trechus* specimens with apparently fully developed wings were also taken. It is known that macropterous individuals of *T. obtusus* do occur in Britain (Loxton, 1982), so it could not be assumed that all winged specimens were of *T. quadristriatus*. Eight of these fully winged specimens were all, however, determined by Mr D. G. Hemmingway as *T. quadristriatus* (Schrank).

Besides the four specimens of *Trichocellus placidus* (Gyll.) taken in the pitfall traps, on 10-3-89, Joyce Payne found one in the nest of a small mammal among *Juncus effusus*.

LIGHT TRAPPING

Over the years 1989-1993 a light trap was run inside an (open) garage window, primarily to sample the moths present in the locality. In general it was run only on what were thought likely to be "good nights for moths". Nevertheless, this amounted to 140 nights in 1990, though considerably fewer in the other years. Strangely, it was only on six nights during August 1990 that more than the odd carabid beetle appeared in the trap. Then, over these six nights, over 50 carabids were trapped. These species are listed in Table 2. The figures in brackets are the numbers taken in the pitfall traps. The six nights concerned also gave outstandingly high catches of moths compared with the norm for this trap.

TABLE 2
Numbers of Carabids obtained by light and pitfall trapping

Species	Light	Pitfall
<i>Amara apricaria</i> (Paykull)	9	1
<i>A. bifrons</i> (Gyll.)	3	25
<i>A. anlica</i> (Panzer)	1	2
<i>Bradycellus harpalinus</i> Serville	16	8
<i>B. verbasci</i> (Dufts.)	21	2
<i>Dromius quadrimaculatus</i> (L.)	2	0
<i>Trechus discus</i> (F.)	1	4
<i>Trechus quadristriatus</i> (Schrank)	4	>8

There is, of course, no information as to where the beetles coming to the light trap originated *Amara apricaria* Paykull, *A. bifrons* (Gyll.), *Bradycellus harpalinus* (Servilk) and *B. verbasci* (Dufts.) are well known as being attracted to light (Lindroth, 1985-86).

COMPARISONS

It is interesting to compare the number of species of carabid found within a 1.18 ha. field and a 0.063 ha. garden in a lowland Yorkshire village (field and garden together, 76 – garden alone, 51) with the numbers in published lists from some far larger areas (see Table 3). It is unlikely that the relatively small numbers from Orkney and Shetland are due primarily to latitude or relative treelessness, for 80 species are recorded from Finnmark, north of latitude 68° (Lindroth, 1985-86).

TABLE 3
Carabids in published lists from various sites

	Number of species	Approx. area (ha.)
Askham Bog (Fitter & Smith, 1979)	51	40
Epping Forest (Buck, 1955)	105	1,400
Monks Wood (Steele & Welch, 1973)	95	157
Orkney (Berry, 1985; Sadler 1993)	50	97,000
Rhum (Steel & Woodruff, 1969)	66	10,680
Sheltland (Berry and Johnson, 1980)	55	143,000
Malham Area (Flint, <i>et al.</i> , 1963)	42	200
Thorne Moors (Skidmore, <i>et al.</i> , 1985; Skidmore n.d.)	138	1,200

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FUNGI OF DOUNE PONDS, STIRLINGSHIRE, WITH SPECIAL REFERENCE TO BONFIRE-SITE SPECIES

ROY WATLING, BRIAN J. COPPINS

Royal Botanic Garden, Inverleith Row, Edinburgh EH3 5LR

AND IAIN C. MUNRO

Dollar, Clackmannanshire FK14 7HU

INTRODUCTION

Bonfire site fungi are well documented (Dennis, 1978; Ellis & Ellis, 1988; Legg, 1991; Petersen, 1970, 1971; Webster, 1952; Wicklow 1988) and cover a wide array of larger fungi ranging from cup fungi ('discomycetes': Ascomycotina) to mushrooms and toadstools ('agarics': Basidiomycotina). Many of the fungi are very specific, e.g. *Anthracobia* spp. and *Tephrocybe* spp., some experimental work has been conducted to attempt to understand why such specificity exists (El-Abyad & Webster, 1968a, 1968b). However, the opportunity to undertake observations from the initiation of a fire until the sites are colonized by phanerogams seldom arises in the field. The third author (I.C.M.) carried out nearly all the fieldwork, assisted by Marjory A. Ness, whilst the other authors examined the collections made during these visits and on the annual forays they themselves made.

DOUNE PONDS

Doone Ponds are located on the outskirts of Doone, a small town on the River Teith in Stirlingshire, 4.43 km from the confluence of waters running from the Pass of Leny and Loch Venacher. In 1983, Stirling District Council entered into an access agreement with Moray Estates Development Company and began managing Doone Ponds as a wildlife conservation site and amenity area. Melt water during the amelioration of the climate at the end of the Pleistocene deposited thick layers of river gravel, the commercial potential of which was realised in the 1950s. Mechanized extraction commenced and continued for over ten years, resulting in a mosaic of ponds over the 40 acre site. As is the case with many similar valley deposits, ground water seeps in and unless pumping is maintained over a long period lakes and ponds develop. This has happened at Doone where small areas of open water have formed almost since the beginning of operations. The surrounding area of waste has been gradually invaded by scrub birch, many kinds of willow (both species and hybrids) and many weedy herbs. The major elements are *Salix caprea* and *S. viminalis*. Some of the original wind-breaks of *Pinus sylvestris* are still present towards the margin of the plot and in places are intermixed with other exotics, e.g. *Rhododendron ponticum*.

The whole area is now managed by the District Council, assisted by Scottish Natural Heritage, especially to encourage wild fowl which are attracted to the three large ponds and two smaller wetland sites.

GENERAL MYCOFLORA OF AREA

Mycologically the area is rich, with a mixture of elements rarely seen together in a single locality, e.g. clay bank 'discomycetes', hypogeous fungi, and early colonists. Thus, regular fruitings of *Phaeolepiota aurea*, often consisting of scores of basidiomes, are found, and many species associated with disturbed soil and buried wood are frequent, e.g. *Lacrymaria lacrymabunda*, *Lyophyllum connatum* and *L. decastes*, *Pholiota gummosa* and troops of *Coprinus comatus*. Over the last two years a large colony of *Tremiscus helvelloides* has fruited at the margin of a copse and is the most northerly record of this jelly fungus in the British Isles. First found by Dr Alan Silverside on a foray of the Botanical Society of Edinburgh in 1991, it has appeared again but fear for its survival might be warranted as the copse is encroaching. This fungus seems to have been spreading in the United Kingdom over the last decade (Watling & Munro, 1993; Watling 1993). *Hebeloma tomentosum* is also found at Doone and is a British rarity.



FIGURE 1

Doune Ponds Reserve: 1 to 3 (A & B) the three study sites.
S = Scrub; W = Open water all year around.

Good fruitings of Russulaceae *Lactarius aspidicus*, *L. glycosmus*, *L. torminosus*, etc. and *Russula aeruginea*, *R. aquosa*, *R. scotica*, etc. have been recorded, in addition to *Cortinarius cinnamomeoluteus* and *C. uliginosus*, *Inocybe agardhii* and *I. flocculosa*, *Amanita muscaria* and *A. vaginata*, *Boletus chrysenteron*, *Chalciporus piperatus*, *Leccinum roseofracta* and *L. versipelle*, and *Laccaria tortilis* – all ectomycorrhizal fungi. Other characteristic mycorrhizals with pine are also present, e.g. *Hygrophorus hypothecus*, whereas *Hymenogaster tener* (Basidiomycotina) and *Tuber borchii* (Ascomycotina), two hypogaeous fungi both associated with willows, are widespread.

The woody debris supports *Phaeomarasmius erinaceus*, *Hapalopilus nidulans* and *Hohenbuehelia reniformis*, etc., in addition to the many terrestrial species, including many agarics (*Cautarellula umbonata*, *Clitocybe odora*, *Collybia tuberosa*, probably on decaying fungi, *Myceena pura*, *M. sanguinolenta*, *Melanoleuca turrita*, a rather uncommon fungus, and *Omphalina cupulatoidea* on moribund *Peltigera*, to name but a few).

Doune is fortunate in having many larger discomycetes in its flora. The more prominent members include a large colony of *Gyromitra infula*, *Helvella corium*, *H. crispa*, *H. cupuliformis* and *H. lacunosa* – all 'saddle-fungi'. Other larger discomycetes include *Geopora foliacea*, *Peziza badia* and *P. limnaea* and *Spathularia flava*.

In contrast, the smaller and less conspicuous cup-fungi include *Ciboria seminicola* on

alder seeds (*Alnus*), the first record for Britain, *Phaeohelotium monticola* on decorticated wood, *Discinella boudieri*, *Pulvinula convexella*, *Octospora humosa* and *Sphaerosporella prunnea* all on soil, and *Fimaria theioleuca* and *Pulvinula cinnabarina* on dung. *Hyphomyces ochraceus*, on decaying Russulaceae, and *Sordaria arenicola* are two less commonly seen 'pyrenomycetes'.

Several other fungi have been recorded by local mycologists on forays etc., but most of the records have been made by the diligent collecting by one of us (I.C.M.). A full list for the area, available at the Royal Botanic Garden, Edinburgh, indicates the richness of the flora and some of the potential colonizers of bare patches which appear in the woodland, including bonfire sites.

SITE HISTORY AND PREPARATION OF THE BONFIRE SITES

After Doune Ponds were taken over as a Nature Reserve a certain amount of clearing and brashing was required by the prescribed management plan. In 1989, when I.C.M. commenced his studies, there were already the remains of one or two old fire sites but it was felt that considerably more information could be gained on the species colonizing such a site if monitoring were to commence on 'Day 1'.

Two heaps of thinnings were already in place as part of the clearing operation and these, designated 1A & 1B, were lit on the first day of April 1990. Two further fires were lit nearly six months later (13.09.90) when the weather was calm enough not to damage adjacent standing vegetation; these sites were designated 2A & 2B. Finally, two sites were selected in order to ascertain whether size was a factor in colonization, 3A being about four times the area of 3B. Bonfires were lit at both sites thirteen days later (26.09.90); the location of all the bonfire sites is shown in Figure 1.

In all cases the sites were raked over two or three days after being lit in order to produce areas of 'burnt ground' rather than sites where there were mixtures of charcoal, thick ash or partially burnt substrate. This treatment improved the finding of specimens in the early stages and seems to have made little difference as charcoal etc. supported few fruiting bodies.

All sites were affected by flooding in the winter months: site 1 was the worst affected, being only about 50mm above the water table for most of the year, if not actually under water!

All the fires were tended continuously during the time they were burning until they died down, ensuring that six circular or slightly oval, sharply delimited burnt areas were formed, with their outer edges consisting of scorched grass tops. The diameter of the six sites were 1A - 4m; 1B - 2.5m; 2A - 3.5m; 2B - 3.5m; 3A - 4m and 3B - 2m.

The material for all the fires was a mixture of *Betula* and *Salix* thinnings with only a single branch of *Pinus* in 3A. All these fires could therefore be considered 'wet hardwood' sites.

METHODS

Sites 1A & 1B were visited once a week until the first species was recorded. From then on the visits increased to 2, 3 or 4, and on one occasion 5 times a week at the height of the season. In the second year, when regeneration was active, observation was more difficult and fortnightly visits were all that could be attempted. When immature specimens were located, they were marked in order to await their maturity and identification. In the case of difficult or critical taxa, material was received at the Royal Botanic Garden, Edinburgh (E) for identification. Material of rare and uncommon species, however easy they were to identify, were also deposited in E. Some collections of discomycetes were identified or confirmed for one of us (I.C.M.) by P. Wilberforce. Collecting continued until autumn 1992 when all the sites had been invaded by mosses and phanerogams and no further additional records were made.

Only the first appearance of each species was recorded and no attempt was made to note the duration of the fruiting season in all taxa.

TABLE I

Complete list of fungi found on bonfire sites indicating obligately and facultatively carbonicolous species and those of chance occurrence.

Species	obligately carbonicolous	facultatively carbonicolous	chance fruiting
BASIDIOMYCOTINA			
AGARICALES			
<i>Coprinus angulatus</i> Peck	+		
<i>Laccaria tortilis</i> (Bolton) Cooke			+
<i>Lyophyllum decastes</i> (Fr.:Fr.) Singer			+
<i>Pholiota highlandensis</i> (Peck) Hesler & Smith	+		
<i>Pluteus minutissimus</i> Romagn.			+
<i>Tephrocycbe anthracophila</i> (Lasch) P. D. Orton	+		
APHYLLOPHORALES			
<i>Clavaria acuta</i> Sowerby:Fr..		+	
<i>C. argillacea</i> Pers.:Fr.			+
<i>Thelephera terrestris</i> Pers.:Fr.			+
LYCOPERDALES			
<i>Lycoperdon perlatum</i> Pers			+
ASCOMYCOTINA			
PEZIZALES			
<i>Anthracobia maurilabra</i> P. Karsten	+		
<i>A. melaloma</i> (Alb. & Schwein.) Boud.	+		
<i>Ascobolus carbonarius</i> P. Karsten	+		
<i>Iodophanus carneus</i> (Pers.) Korf		+	
<i>Lamprospora crec'hqueraultii</i> var. <i>macrantha</i> Boud.			+
<i>L. dictydiola</i> Boud.	+		
<i>Peziza badia</i> Pers.			+
<i>P. echinospora</i> P. Karsten	+		
<i>P. petersii</i> Berk. & Curtis	+		
<i>P. sepiatra</i> Cooke		+	
<i>P. violacea</i> Pers.	+		
<i>Plicaria anthracina</i> (Cooke) Boud.	+		
<i>Pyronema omphalodes</i> (Bull.) Fuckel		+	
<i>Scutellinia scutellata</i> (L.) Lambotte			+
<i>Sepultaria semi-immersa</i> (P. Karsten) Masee			+
<i>Sphaerosporella brunnea</i> (Alb. & Schwein.) Svrcek & Kubicka		+	
<i>Tricharina gilva</i> (Boud. ex Cooke) Eckblad	+		
<i>Trichophaea gregaria</i> (Rehm) Boud.	+		
HELOTIALES			
<i>Ascocoryne sarcoides</i> (Jacq.) Grove & Wilson			+
<i>Bryoscyphus marchantiae</i> (Berk.) Spooner			+
<i>Hymenoscyphus calyculus</i> (Sowerby) Phill.			+
SORDARIALES			
<i>Strattonia carbonaria</i> (Phill. & Plowr.) Lundq.	+		
<i>S. minor</i> Lundq.	+		
SPHAERIALES			
<i>Xylaria hypoxylon</i> Grev.			+

RESULTS

The full list of fungi recorded is given in Table 1 and those found at each site in Tables 2, 3, and 4, together with the time and location of their first appearance (i.e., distance from the edge; (E) is taken as a strip about 150mm wide inside of the perimeter which, for the first year at least, was fairly clearly defined. Thereafter its position was estimated by reference to known objects taken as reference points).

TABLE 2
Data of appearance and distribution of species collected at site 1.

Site 1A Lit 010490 size 4m.				
Date d/m/y	Days after ignition	Distance in from edge (m)	Species	Remarks
160690	77	E	<i>Ascobolus carbonarius</i>	
220690	82	E	<i>Peziza violacea</i>	
		E	<i>Trichophaea gregaria</i>	
090890	131	E	<i>Tricharina gilva</i>	
170890	139	E	<i>Pluteus minutissimus</i>	
010990	153	E	<i>Peziza echinospora</i>	
080990	183	E	<i>Clavaria acuta</i>	
051090	188	—	<i>Iodophanus carneus</i>	On rabbit dung
071090	190	E	<i>Ascocoryne sarcoides</i>	On small charred stump
		E	<i>Xylaria hypoxylon</i>	On small charred stump
2230491	389	0.3	<i>Peziza petersii</i>	
100591	406	0.3-0.6	<i>Peziza sepiatra</i>	Only 2 or 3 small ascomata
2230691	450	E	<i>Coprinus angulatus</i>	Small nos. regular thereafter
2220991	538	0.5	<i>Clavaria argillacea</i>	3 poor basidiomes
		E	<i>Sepultaria semi-immersa</i>	
1100892	863	E	<i>Thelephora terrestris</i>	Made little growth
0300892	883	0.6	<i>Lycoperdon perlatum</i>	Typical basidiome
Site 1B Lit 010490 Size 2.5m.				
160690	77	E	<i>Ascobolus carbonarius</i>	
220690	82	E	<i>Peziza violacea</i>	
		E	<i>Trichophaea gregaria</i>	
020591	398	E	<i>Peziza sepiatra</i>	Poor ascomata
		E	<i>Peziza petersii</i>	Poor ascomata
1250891	513	0.3	<i>Clavaria acuta</i>	Typical basidiome
		1.25	<i>Laccaria tortilis</i>	Few basidiome, but well formed
270992	852	0.3	<i>Lamprospora dictydiola</i>	

DISCUSSION

A glance at the site lists of fungi reveals the large number of species (35%) which would not normally be regarded as carbonicolous. Using Ellis and Ellis (1988) as a guide, only 50% of the genera and 33% of the species listed therein as carbonicolous were recorded during the present investigation. The few basidiomycetes recorded are not included in this

calculation. Waterlogging at the six sites during the winter months, even when burning was undertaken, probably inhibited growth. The appearance of many species not normally considered carbonicolous suggested their mycelium may have survived the fire. *Tuber borchii* was found at site 3B in the second year and may have survived on deeply seated roots or attached to a newly invading *Salix* root. It could be that the soil temperature underneath the fire was not high enough to kill the mycelium of many of the fungi already present; furthermore, the mycorrhizal and wood-rotting fungi present were possibly colonizing the site because of lack of competition and not in a quest for nutrients.

Of the truly carbonicolous taxa, the only ones to produce typical fruiting bodies were *Anthracobia maurilabra*, *Ascobolus carbouarius* and *Sphaerosporella brunnea*. All the others, including the non-pyrophilous species and basidiomycetes, were either present in very small numbers and/or did not reach their maximum size recorded in Ellis and Ellis (1988). Thus, only *Peziza echinospora* and *P. violacea* grew to over half the maximum size recorded and *P. petersii*, *P. sepiatra* and *Plicaria anthracina* barely reached the minimum size recorded.

TABLE 3
Data of appearance and distribution of species collected at site 2.

Site 2A Lit 130990 size 3.5m.				
Date (d/m/y)	Days after ignition	Distance in from edge (m)	Species	Remarks
281090	45	Scattered	<i>Anthracobia maurilabra</i>	
150991	203	E	<i>Peziza violacea</i>	
030591	223	Scattered	<i>Strattonia carbonaria</i>	
		"	<i>Strattonia minor</i>	
		"	<i>Anthracobia melaloma</i>	Few ascomata but did not increase
200591	230	E	<i>Peziza sepiatra</i>	
260691	267	E	<i>Peziza echinospora</i>	
280691	269	0.6	<i>Plicaria anthracina</i>	Poorly developed ascoma, 10mm in diam.
250891	327	E	<i>Peziza badia</i>	Developed into big cluster
200991	353	0.3	<i>Lyophyllum decastes</i>	Typical cluster
111091	374	0.6	<i>Tephrocybe anthracophila</i>	
130492	559	—	<i>Bryocyphus marchantiae</i>	On <i>Marchantia polymorpha</i>
Site 2B Lit 130990 Size 3.5m.				
171090	34	Scattered	<i>Anthracobia maurilabra</i>	
211090	38		Huge amounts of <i>A. maurilabra</i> now all over site	
150491	215	E	<i>Peziza violacea</i>	
		0.75	<i>Peziza echinospora</i>	
		Scattered	<i>Anthracobia melaloma</i>	
200591	250	0.3	<i>Plicaria anthracina</i>	Poorly developed ascomata
290591	259	1.75	<i>Pyronema omphalodes</i>	Not extensive development
050691	266	E	<i>Coprinus angulatus</i>	
160791	307	0.6	<i>Peziza badia</i>	Smaller than those on 2A
250791	316	E	<i>Sphaerosporella brunnea</i>	Finally large ascomata formed
150791	337	E	<i>Thelephora terrestris</i>	Made little growth
100892	698	E	<i>Sepultaria semi-immersa</i>	

TABLE 4
Data of appearance and distribution of species collected at site 3.

Site 3A Lit 260990 size 4m.				
Date (d/m/y)	Days after ignition	Distance in from edge (m)	Species	Remarks
130691	261	E	<i>Peziza echinospora</i>	
		0.3	<i>Peziza violacea</i>	
		0.3	<i>Ascobolus carbonarius</i>	
		0.3	<i>Hymenoscyphus calyculus</i>	On charred twig under grass
160691	264		<i>Coprinus angulatus</i>	
200791	298	1.0	<i>Pholiota highlandensis</i>	
161091	386	0.3	<i>Tephrocybe anthracophila</i>	
160592	599	E	<i>Scutellinia scutellata</i>	Also outside burnt area
180892	685	E	<i>Sphaerosporella brunnea</i>	
021092	743	1.0	<i>Lamprospora</i>	
			<i>crec'hqueraultii</i>	
			var. <i>macrantha</i>	Also outside area
Site 3B Lit 260990 Size 2m.				
130691	261	0.6	<i>Peziza echinospora</i>	
160691	264	Scattered	<i>Coprinus angulatus</i>	
200691	268	Centre	<i>Pholiota highlandensis</i>	
200691	268	E	<i>Ascobolus carbonarius</i>	
030791	281	0.6	<i>Peziza praetervisa</i>	Poor ascoma;
160791	294	0.3	<i>Scutellinia scutellata</i>	
080891	317	Centre	<i>Pyronema omphalodes</i>	Very small patch
250891	334	0.5	<i>Peziza badia</i>	
200991	360	E	<i>Tuber borchii</i>	A chance find
011091	372	0.3	<i>Laccaria laccata</i>	
150592	599	E	<i>Lamprospora</i>	Started outside site
			<i>crec'hqueraultii</i> var. <i>macrantha</i>	
250692	640	0.3	<i>Sphaerosporella brunnea</i>	
170792	662	E	<i>Sepultaria semi-immersa</i>	
120892	688	1.0	<i>Ombrophila violacea</i>	Poor ascoma

Anthracobia is a genus considered to colonize all bonfire sites, but at Doune it had a most irregular distribution. In 2.5 years it was not recorded once on sites 1A or 1B, nor did it appear on 3A or 3B in the 2 years they were critically studied. On sites 2A & 2B, however, the situation was quite different. After about 35 days *A. maurilabra* began to appear and numbers on 2A built up in a few weeks until at maximum the total population was of the order of several hundred ascomata. On 2B high levels of fruiting were reached at about 38 days and by 45 days probably tens of thousands of ascomata were present. From the edge of the site several plate-sized patches were visible as diffused brownish areas where the numbers were highest. At the same period several hundred ascomata were found at a site about 10m away where local fishermen had boiled a kettle of water; this site could not have been very hot. By late December the peak fruiting had passed but the remaining ascomata survived a period of inundation with water and for a short time snow and ice. After 169+ days (1.03.1991) very few could be found.

The appearance of *Anthracobia maurilabra* after the soil had been heated by a small fire sufficient to boil a kettle of water was confirmed in a separate observation made in the autumn of 1993. After 61 days fruiting was occurring associated with *Iodophanus carneus*.

Trichophaea gregaria had probably the longest fruiting period of all the pyrophilous species seen; although a few aseomata could be found there until quite late in the year on sites 1A & 1B only. *Pyronema omphalodes*, characteristically seen as large sheets, was rather poorly represented, the biggest patch being only 50-60mm in diameter. The inconspicuous pyrenomycetes *Strattonia carbonaria* and *S. minor* were recorded only from sites 2A & 2B, although they may have been overlooked at the other sites; the disturbance necessary to locate their aseomata had to be minimized. Of those basidiomycetes identified, *Coprinus angulatus* was the only species to appear regularly and to reach full size, unlike *Pholiota highlandensis* which seldom produced other than stunted basidiomes. *Clavaria acuta*, which appeared in the same spot two years running, is very common on peat-based composts subjected to steam sterilization (Watling & Dobbie, 1991).

It is worth noting that *Pulvinula convexella*, which in a good year normally occurs at Doune in tens of thousands of aseomata on loamy banks in a good year, took quite some time to reach the bonfire patches. *Sepultaria semi-immersa*, which may be associated with tree roots, was also widespread on bare soil, old mole-hills etc. in the adjacent woodland areas; it was never as plentiful as *Pulvinula*. Both *Scutellinia scutellata* and *Lamprospora crec'hquerandii* var. *macrantha* were also found in the adjacent woodland and on site 3B one observed the exploitation of the bonfire site by populations of the *Lamprospora* known to be outside the perimeter of the fire site. The fruiting pattern of the colony changed: maturing towards, and then across, the site. It was on this same site that an aseoma of *Tuber borchii* was found and finally *Ombrophila violacea*, a proposed British Mycological Society Red Data list taxon (Ing, 1992).

As described above the sites were considered 'wet hardwood' sites but it was possible during the study period to compare them with 4 to 12 groups of 'well-drained softwood' sites which were examined in-between times. Three of these groups carried vast numbers of *Pholiota highlandensis* and *Tephrocybe* spp. All had *Rhizina undulata* in varying amounts and two had spectacular displays of *Geopyxis carbonaria*. Later on, one of the soft-wood sites supported huge numbers of *Armillaria gallica* Korb. & Marxmüller; when the *Plicaria* spp. and *Peziza* spp. appeared they were both more numerous and larger than those on the 'wet hardwood' sites.

CONCLUSIONS

The Doune Ponds site has an extremely interesting mycoflora with many rare or uncommon fungi, both micro- and macrospecies. Some of these species are restricted to willow and birch scrub and may be eventually lost as the woodland matures.

One of the ways of managing the site has been to make paths to direct visitors and to cut brash in some areas. The opportunity was therefore taken to examine the pyrophilous fungi which might develop there. Characteristic fungi of bonfire sites have been found but certain peculiarities have been noted, especially in the size of basidiomata and aseomata. Many of the bonfire sites have been invaded by fungi found elsewhere in the woodland and it is suggested that the temperature of the soil during burning may have played an important part in affecting the colonization of these sites.

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FIELD NOTE

Gentianella amarella ssp. *septentrionalis* in Yorkshire

On 31st July 1990 seven plants of a small felwort, *Gentianella amarella* (L.) Boerner, were discovered by the writer growing in short, sheep-grazed *Festuca* – *Sesleria* grassland at Kettlewell. Unlike our usual felwort which has blue flowers, these plants had the corolla white on the inside with a maroon outer surface and fitted exactly the description of *Gentianella amarella* ssp. *septentrionalis* (Druce) N. Pritch. This determination was subsequently confirmed by Dr Noel Pritchard, BSBI referee for Gentianaceae.

The site was a steep, north-east facing slope at an altitude of approximately 230 metres. Other associated species were *Carex panicea* and *Primula farinosa*.

On 31st August 1990 some small felworts were found by members of Swarthmore Botany Club, alongside a track near Kidstones Pass north of Buckden. Because of their generally squat appearance it was thought that these, too, might be *G. amarella* ssp. *septentrionalis*. It was too late in the season to be sure at that time but the identification was confirmed the following summer.

It is possible that a felwort found by Joyce and Sam Hartley, flowering in June 1989 near Coniston, was also of this subspecies but, sadly, they have been unable to refind the plant at the site.

The Kettlewell site was revisited in July 1992 and the number of plants had increased to about twenty.

Until recently, this subspecies was thought to be endemic to north-west Scotland but, prior to the Kettlewell discovery, Dr Pritchard had identified specimens from limestone in Perthshire and from dunes on Holy Island and the Northumberland coast. It would obviously be worthwhile to look out for it in other base-rich areas in northern England.

Phyl Abbott

BOOK REVIEWS

Barn Owls: Predator-Prey Relations and Conservation by Iain Taylor. Pp. xvi + 304, including 119 b/w maps, diagrams and photographs. Cambridge University Press. 1994. £19.95.

The status of the barn owl in the United Kingdom has been a matter of concern for some time with numbers apparently declining fairly steadily. Worldwide the picture is rather different, with this species thriving over much of its range. It is nevertheless an opportune time for a book to appear on the ecology of this species in this country. The author studied the barn owl for fifteen years up until 1992 in four study areas in southern Scotland. With this wealth of experience and a wide knowledge of the international literature the author is able to provide the reader with an excellent, comprehensive and readable account.

The book contains seventeen chapters. Following the introductory chapters on methodology, geographical distribution and variation the next four chapters dwell on the prey, how it varies between locations, how it is obtained and selected as well as how its numbers fluctuate. After this the main thrust of the book is concerned with reproduction through the sequence of breeding seasons, nest sites, courtship, production of young and dispersal. The account is completed with accounts of mortality, population size and regulation and conservation. At the end of each chapter is a useful short summary.

One of the most striking features is the author's ability to involve data from many sources, such as the egg laying period derived from ten countries (and three continents) and then complement this with his own extensive data showing, for example, the mean number of young fledged in 13 successive years. He finds an excellent balance between these various sources which gives the book considerable authoritative standing. The information is lucidly presented in text, line drawings, photographs and diagrams. This is an invaluable book for the amateur and professional ornithologist and ecologist as well as the conservationist (with a careful analysis of the causes of decline in the U.K. and possible remedies) and more widely for anyone with a serious interest in natural history.

MJD

Sharks of Hawaii: their biology and cultural significance by Leighton R. Taylor. Pp. viii + 126, including numerous colour plates & line drawings. 1993. University of Hawaii Press, Honolulu. \$19.95 hardback.

Although this book is obviously targetted at a Pacific readership, sharks are never out of the news and so it is valuable to have an authoritative source book which presents the facts in a straightforward manner without imposing 'Jaws' scariness and which dispels widespread misconceptions. As well as providing detailed descriptions of 37 different sharks to be encountered in Hawaiian waters, a section of the book is devoted to a detailed study of shark biology which will be of greater interest to readers of *The Naturalist*. Of less interest, but nevertheless fascinating to read, are details of Hawaiian legends and artifacts which have arisen through local culture. The book is packed with full colour plates (both photographs and paintings – the latter by Michael Cole) and line drawings which superbly portray all aspects of shark form and behaviour.

IJH

Natural High by John P. Wiley Jr Pp. 121. University Press of New England 1993. \$12.95 paperback.

John Wiley writes essays on popular science for the magazine *Smithsonian* (of the Smithsonian Institution in the U.S.), and if the two dozen or so reprinted here with short connecting passages are typical, they deserve to be better known on this side of the Atlantic. Not all are about natural history but, as the author says, they are about learning to

see the natural world around us. They also emphasise the interconnectedness of everything in the universe, animate and inanimate, and emphasise that man cannot isolate himself from events that occur in nature. Naturalists are catered for in essays on perturbing the natural world, life in the canopy of tropical forests, urban wildlife, rooftop gardens, marine pollution, and the persistent effects of oil spills. The often ignored pollution by unnecessary lights at night is crisply brought to notice in five pages. This is now a serious problem for observational astronomers, and ensures that many of us now never see the full glory of the heavens. It also often needlessly consumes energy, thereby adding to air pollution, and can confuse migrating birds. Means of mitigating such problems, which actually save money, are suggested. The theme of conservation is seldom far below the surface and sometimes the writer indulges in philosophy. Just the thing from which to read single articles when one has a few minutes to spare.

GF

A Key to the British Species of Freshwater Cladocera by D. J. Scourfield and J. P. Harding. Pp. 57. Freshwater Biological Association, Ambleside. 1994 reprint. £6 paperback.

Originally published in 1941, this key became an immediate classic, used by amateurs and professionals alike. By providing an excellent means of identification it was instrumental in introducing many, including the reviewer, to the study of these organisms. Clear and logical and with illustrations on which characteristics were unambiguously pinpointed and related precisely to given points in the key, it was a model of clarity. A second edition, in 1958, included minor revision and re-arrangement, but editorial tinkering removed the very device which so effectively co-ordinated key and illustrations. By 1966, substantial revisions were needed, but a third edition, essentially unchanged, appeared and shortly afterwards an amendment slip that drew attention to a few recent advances was inserted in copies sold thereafter, but this was only a stop-gap measure. Now, more than a quarter of a century later, this version, with its amendment slip has been reprinted unchanged. In effect the 1958 issue, it is woefully out of date and misleading. In the past 36 years much has been discovered about the structure, affinities, taxonomy, ecology, habits, genetics and distribution of these animals, but the reader will not find this information here.

What needed to be done? Users are not told that the very name 'Cladocera' embraces a heterogeneous assemblage of four groups and is best avoided as a taxon, though it is a convenient descriptive term: the status of members of such widely studied genera as *Daphnia*, *Moina* and *Bosmina* has changed so much that their entire keys need to be re-cast and the nomenclature revised: generic re-assignments are ignored and *Tretocephala*, *Oxyurella* and *Megafenestra* are not to be found, while *Disparalona* and *Pseudochydorus* still key out to the wrong genera more than 25 years after their true affinities were established; *Dunhevedia crassa*, added to our fauna some 20 years ago and a member of a hitherto unrepresented genus, receives no mention; the key takes one to *Echinisca tenuicornis* instead of to *Macrothrix rosea* and to the synonymized *Diaphanosoma leuchtensbergianum*; the taxonomic value of head-pores in especially the Chydoridae, where, for example, they provide a diagnostic distinction between the very similar *Alona affinis* and *A. quadrangularis* goes unnoticed; the male of *Macrothrix hirsuticornis* is unknown; hybrids of planktonic species of *Daphnia* are not mentioned; distributional data, e.g. for *Daphnia magna*, *Euryercus glacialis* (the latter not keyed out) and several others are out of date and misleading, and so one could go on.

These are serious criticisms. Incorrect identification can lead to chaos as an example shows. According to the key, the planktonic *Daphnia* of Esthwaite Water (English Lake District) is a form of *D. hyalina*, and as such it as recently treated in what purported to be a 17-year study of its dynamics. In fact three morphologically and genetically distinct taxa – none of them assignable to *D. hyalina* – are involved. Of these, two had already been shown to differ in ecology and behaviour in that very lake. The relevant work – published

in 1983 – receives no mention in the key even though it dealt with the open water form of *Daphnia* in the district for which detailed, but misleading, records are cited.

It is sad that this work, which when published more than 50 years ago was such a splendid work, and could so remain, should be so devalued. Its re-issue without revision does grave disservice both to the study of these animals and to its distinguished author. If the aim is to serve science rather than make money it should be withdrawn.

GF

Hydrology and Wetland Conservation by **Kevin Gilman**. Pp. 101, plus 4 b/w plates & 62 figures. Wiley, Chichester. 1994. £14.95.

The title of this book is somewhat misleading as it concentrates on the measurement and behaviour of water in wetlands rather than on the management of water-tables for the benefit of water conservation or wildlife conservation.

The examples of water-table behaviour are taken from 7 site investigations undertaken in the U.K. by the Institute of Hydrology and the former Nature Conservancy Council. The use of 'dip wells' to measure ground movement as well as water-table fluctuations is described. This method and lysimeters can then be used to construct water balances. The work neatly dispels two particular myths. Firstly, that open drains/ditches give rise to a major reduction in water-tables over large distances; in fact the effect can be as little as 2m and some drains recharge adjacent wetlands with water in summer. Secondly, that evapotranspiration from wetland vegetation is often significantly less than potential evapotranspiration. It is clear that an understanding of the hydrology of many sites is still rudimentary. I know from my own personal experience of working on Crymlyn Bog that the text's description of the hydrology of this site is limited compared to the known behaviour where the water-table is rising steadily over large parts at an average of 1 to 2cm per year.

For a self-confessed novice of 'physical geography', this book helped me understand the principles used by hydrologists to calculate the various components of a water balance for a site. This is a far more accessible text than many others on the subject, and will be particularly useful to those actively involved in managing wetlands for whatever purposes.

ADH

The Scientific Management of Temperate Communities for Conservation edited by **I. F. Spellerberg, F. B. Goldsmith and M. G. Morris**. Pp xv + 566, including numerous figures & tables. Blackwell Scientific Publications. 1991. £45.00 hardback, £26.50 softback.

This book will appeal to a large number of professional conservationists. It is a symposium volume of 21 papers presented at the 31st British Ecological Society Symposium, with papers mainly from the U.K., but also from Norway, Netherlands, U.S.A. and New Zealand. It is 22 years since the production of the earlier symposium volume *The Scientific Management of Plant and Animal Communities for Conservation*. This was catalysed by the unsuccessful campaign in the 1960s to save parts of Upper Teesdale from being drowned under the Cow Green Reservoir. This latest volume gives a more up to date account of the same conservation problems, and concentrates more on aspects of large-scale management, with papers on biological diversity, large mammals, fish, invertebrates, creative conservation, modelling landscape change and the effects of different management regimes on species composition in woodlands. As with most symposium volumes, there is little continuity between the papers, but they do complement one another. It is difficult to be over-enthusiastic about this volume, as it is another in a long line on the same themes.

ADH

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